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RANGER BLOCK III

LAUNCH CONSTRAINTS PLANNING DOCUMENT

EPD 130

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PART I. INTRODUCTION

1. PURPOSE AND GROUND RULES

A. Purpose

The requirement for this document is placed by the Ranger Project Manager on the Systems Division, JPL. The "Ranger Project Policy and Requirements" document, EPD 65, Rev. 1, 8 March 1963 delineates the Launch Constraints Planning Document, in part, as follows:

"The purpose of this document is as follows:

(1) To describe the requirements for tracking and telemetry support in the period from launch through launch plus three hours.

(2) To provide information which will describe the resources available to meet these requirements.

(3) To examine all other areas such as spacecraft, range safety, launch vehicle, etc., for constraints to the design of the launch period and launch window.

(4) To develop a launch constraints plan based on the information described in Sections 1, 2, and 3 and the characteristics of the near Earth trajectories. This plan will be a project requirement when signed by the Project Manager.

"This document is to be prepared early in the Project to guide other actions.

"This document will be used as a guideline to the Program Requirements Document (PRD), the Space Flight Operations Plan (SFOP), the Assembly and Operations Plan (AOP), S/C-LV integration document, the S/C-DSIF-SFOF interface document and other interface documents."

B. Ground Rules

Ground rules have been established by the Ranger Project Office to help clarify the purposes of this first issue of the launch constraints document. These ground rules are as follows:

(1) No research will be necessary by the contributors for the first issue. Rather, this first issue will contain only current knowledge, and gaps in this knowledge will be acknowledged and so identified. Subsequent revisions to the document will become more detailed and thorough.

(2) This document is not intended to replace existing documents. It is rather an accumulation of existing knowledge relative to the selection of the launch period or launch window with particular emphasis on those areas which heretofore have not been clearly understood this far in advance of the launch. Special emphasis will be placed on describing the tracking and telemetry coverage necessary to support the coverage requirements.

(3) This first issue assumes that the spacecraft/vehicle system is functioning properly, and consideration is not given to launch constraints which result from a spacecraft/vehicle system failure. For example, this document will describe the launch constraints which result from inadequate tracking coverage, even though all systems are functioning properly. Similarly, attention will be directed to the length of time the vehicle can spend on the pad before requiring revalidation, retesting, etc. Thus, launch constraints can arise even when all systems are functioning as designed. In other words, launch constraints caused by exceeding the design limits or man-made policy limits on the system will be considered.

As stated above, launch constraints which occur as a result of system failures are not considered in this document. For example, a launch can take place even if various failures occur in the telemetry system. Certain telemetry channels, however, are mandatory and must function properly before a launch is permitted. Similarly, all communication lines from the SFOF to the DSIF do not have to be in at the time of launch. Some can be down for one reason or another and not hold the launch. Problems of this nature are not treated in this issue.

Documents are published which do describe the launch constraints that result from system failures. These documents and the Launch Constraints Planning Document must be used together to obtain a complete picture of the possible constraints to the launch.

(4) Launch Constraints which would occur as the result of conflicts with other projects (Surveyor, Mariner, Pioneer, etc.) are not discussed in this document. This problem is, however, of real concern. Its importance should not be underestimated. However, the Ranger Project Manager has stated that consideration of this problem is beyond the scope of this first issue.

(5) Publication of the first edition of the document is scheduled for July 26, 1963.

(6) These ground rules have been established for this first issue only, and they will be reviewed prior to publication of subsequent editions. Comments and recommendations for the subsequent editions are welcome.

C. Scope

This document delineates requirements placed by and the capabilities of each of the four (4) systems which constitute the Ranger Block III Project. These are the spacecraft and launch vehicle systems, the Space Flight Operations Facility (SFOF) and the Deep Space Instrumentation Facility (DSIF). In addition, the requirements and capabilities of the Atlantic Missile Range (AMR) are also described. The information in this document discussing each of these five (5) areas is obtained from a variety of sources. Each of these sources is acknowledged at the conclusion of this Part I. The purposes of these acknowledgements are to assign due responsibility for the accuracy of the material and to extend credit to the contributors.

2. ORGANIZATION OF DOCUMENT

The content of the Launch Constraints Planning Document is arranged in a manner intended to make it useful both during the months prior to launch and during the actual launch operations. The document is divided into three parts and a series of appendices. The three parts are titled, Part I. Introduction; Part II. Launch Constraints; and Part III. Launch Operations Plan.

Part II, Launch Constraints is a summary of all launch constraints, delineated in detail in the supporting appendices. The single exception to this is the constraints due to inadequate tracking and telemetry coverage; these constraints are discussed in Part III.

Part III, Launch Plan Operations represents the final product of the Launch Constraints Planning Document. It is a presentation of the recommended launch plan incorporating the launch constraints summarized in Part II and described in detail in the appendices. These constraints will be indentified in Part III, but rarely discussed at any length. Part III primarily will consist of easy-to-read charts, maps, and graphs. Those documents that are pertinent to the determination of launch constraint not within the scope of the Launch Constraints Planning Document are listed at the conclusion of Part III.

Appendices are descriptions in depth of the trajectory characteristics, the requirements for tracking and telemetry coverage, the capabilities of the Atlantic Missile Range (AMR) and the Deep Space Instrumentation Facility (DSIF) to support these requirements, and the launch constraints which result from other considerations, such as spacecraft and launch vehicle hardware, operational limitations of the DSIF and Flight Operation Facility range safety, etc. The appendices are provided for thorough discussions of the launch constraints during the months preceding the launch.

3. ACKNOWLEDGEMENT OF SOURCES

Appendix A: Section I.C. - M. Holritz, Ranger Block III DSIF Project Representative

Section II.B. - D. Curkendall, Ranger Midcourse Maneuver Engineer with assistance from L. Bronstein, Section 312, Ranger Project Engineer

Table B.3 - W. Sjorgren, Ranger Orbit Determination Engineer, D. Curkendall

Section III - A. E. Dickinson, Ranger Spacecraft Data Analysis Team (SDAT) Director

/)

Appendix C: - L. S. Joyce, Ranger Block III Launch Constraints Cognizant Engineer

Appendix D: Section III - A. E. Wolfe, Spacecraft Systems Manager
Section IV - W. Lane, Ranger Launch Vehicle Project Representative
Section V - R. Crabtree, Launch Operations Supervisor
Section VI - P. J. Rygh, Spaceflight Operations System Manager
Section VII - M. Holritz

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Part II. LAUNCH CONSTRAINTS

1. INTRODUCTION

This portion of the document summarizes all the launch constraints that exist and the effect these constraints have on the design of the launch plans. It should be remembered that no consideration is given in this issue of the Launch Constraints Document to those constraints that result from system failures or when the Ranger schedule conflicts with those of other projects. Only launch constraints which exist even when all systems function as planned are considered herein.

These constraints are described in Paragraphs 2 through 8 following.

2. RANGE SAFETY

To ensure the safe overflight of land masses, AMR Range Safety determines the launch azimuths that are permissible.

A waiver request has been prepared for Range Safety requesting permission to launch Ranger Block III missions in a launch azimuth sector between 90 and 114°. Range Safety has not completed their evaluation of this request.

Range Safety has allowed Ranger Block 2 and the Mariner R vehicles to be launched in a sector between 93 and 111°. However it is hoped that a full sector between 90 and 114° will be granted so that the probability of launching within the alloted launch window and launch period will be increased.

3. SPACECRAFT

There are no constraints to the launch window caused by the spacecraft. However, the spacecraft design does definitize the length of the launch. The present Ranger Block III launch periods are eight days long. Further trajectory design may cause one or two days at the end of each launch period to be eliminated. It appears that the launch periods will be at least six days long.

4. LAUNCH VEHICLE

The following constraints on the duration of the launch window result from certain characteristics of the launch vehicle:

(1) The Atlas LOX system limits the launch window after LOX topping to two (2) hours.

(2) The Agena horizon sensor will occasionally cause the elimination of the latter 1/5 of the RA-8 and RA-9 launch windows.

The sensors may also eliminate complete days of the RA 6 through 9 launch windows. LeRC is pursuing a solution to this problem.

The launch may also be constrained because of the presence of cold clouds in an area which will influence the sensors.

Part III will include any constraints to the launch due to the Agena horizon sensors.

5. LAUNCH OPERATIONS AT AMR

Launch operations at AMR present no constraints.

6. FLIGHT OPERATIONS FACILITY

The following communication links must be operating satisfactorily before a launch is permitted:

(1) A voice line and a TTY line from JPL Pasadena to JPL Cape Canaveral

(2) Communications between Cape Canaveral and Antigua or alternate. Communications between Cape Canaveral and the tracking station providing the post second burn tracking data.

(3) A TTY line(s) between JPL Pasadena and the mandatory DSIF stations(s).

Other than those stated above, no constraints to the launch are imposed by the present Flight Operations Facility provided the facility is functioning properly.

7. DSIF

DSIF imposes no constraints except those mentioned in Paragraph 8.

8. TRACKING AND TELEMETRY COVERAGE

Since the launch constraints that can result from inadequate tracking and telemetry coverage are the most complex constraints to develop, a progressive method of four phases has been devised to ascertain and define such constraints.

Phase 1. The description of the tracking and telemetry coverage requirements placed by the Ranger Project on the AMR and the DSIF are developed in Appendix B.

Phase 2. The general or overall capabilities of the AMR and the DSIF in response to these requirements are described in Appendix C.

Phase 3. These capabilities are summarized as potential constraints in Appendix D.

Phase 4. The determination of whether the tracking and telemetry consideration do, in fact, become launch constraints is highly dependent upon launch day and launch azimuth. For this reason, they must be treated as part of the day-to-day launch constraints acknowledged in the preparation of the Launch Operations Plans. These plans are presented in Part III of this document. Part III then, will, by itself, be complete and sufficient for real time decision making during the conduct of the launch operation.

Phase 1 has been thoroughly treated in Appendix B of this issue of EPD 130. However only initial planning in Phases 2, 3 and 4 has been completed. Phases 2, 3 and 4 will be completed in Revision 1, scheduled for publication on 1 November 1964, and the daily revisions which will be prepared during the launch period.

Part III. Launch Operations Plan

1. INTRODUCTION

In its final form, Part III will contain the detailed minute-by-minute launch plan and all constraints which can influence the launch operations. It is, of course, incomplete at this early date. Revision to the plan will be issued on a day-by-day basis as the launch attempts are made during the actual launch period. However, a typical day has been chosen to illustrate how the charts and maps will be prepared for each launch day.

An Earth map of the Earth track for a launch on December 2, 1963 is presented in Appendix C. A similar map will be prepared for each launch day.

Included in Appendix C is a typical Bargraph based on the trajectory data for the December 2, 1963 launch. It shows as a function of launch azimuth the tracking telemetry coverage in support of the tracking and telemetry coverage requirements. This chart will show the launch azimuths on which coverage is incomplete. Additionally, it affords a means for a quick evaluation of any change in coverage capability as a result of equipment failure during the countdown. Bargraphs of this nature will be prepared on a day-by-day basis describing, for each launch plan, all appropriate factors associated with that plan. Thus, constraints due to inadequate tracking and telemetry coverage will be summarized, as well as constraints due to the Agena horizon sensor. Esspecially favorable launch azimuths will be identified.

Finally, it is planned to have available during the operations a large wall map 8 x 20 feet of the 90 to 114° azimuth corridor from Cape Canaveral to Australia. This map will show, in appropriate detail, the incremental changes in tracking telemetry coverage as the launch azimuth is varied. The bargraph and chart will be drafted from this map.

2. OTHER DOCUMENTS CONTAINING LAUNCH CONSTRAINTS

As stated in Part I, this first issue of the Launch Constraints Planning Document is not considering constraints due to system failures. Obviously, such failures can occur and can constrain a launch. The following documents or their equivalents must be consulted for information pertaining to this subject:

(1) Launch and hold criteria

(2) System test and operations manual (STOM)

(3) Test and operations plan (TOP)

APPENDIX A. Ranger Trajectories

I. INTRODUCTION

This appendix will point out briefly the parameters which influence the near-Earth portion of lunar trajectories in general and describe the Ranger near-Earth trajectories in particular. No attempt will be made to describe the design process but rather only the results will be presented.

At present the final trajectories for Ranger are not available. However, the information included in the Launch Constraint Planning Document will bracket the expected range of parameters in the near-Earth portion of the final trajectories.

II. THE ASCENT TRAJECTORY

The Ranger spacecraft for the Block III mission is to be delivered to injection by the Atlas D/Agena B launch vehicle. As the vehicle leaves the launch pad it will climb vertically for approximately 15 seconds during which time the Atlas rolls to the proper azimuth angle that is determined by the lift-off time. After the initial vertical rise, the vehicle pitches over into a zero lift trajectory guided only by the open-loop Atlas autopilot. Approximately 2 1/2 minutes after lift-off, the booster engines are jettisoned and the vehicle continues under the power of the sustainer engine only. At this time the ground-based guidance loop is closed and the sustainer guides the vehicle to the proper Atlas cut-off conditions. Following Atlas/Agena separation and a coast period determined by the Atlas guidance system, the Agena stage (oriented approximately in a local horizontal attitude) ignites and injects the spacecraft/Agena combination into a 100-nautical-mile parking orbit. Following another coast period in the parking orbit, the Agena engine re-ignites and accelerates the spacecraft to the prescribed injection energy. The spacecraft is then separated and the empty Agena stage executes a yaw turn and performs a retro maneuver in order to prevent its possible impact of the planet.

Figure A-1 is a plot of a typical powered flight profile in the plane of the trajectory. The figure depicts the downrange distance traversed versus altitude from launch through the time of Agena retro maneuver.

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III. THE NEAR EARTH TRAJECTORY

Lunar trajectories can be approximated by a single geocentric conic ellipse whose perigee is nearly equal to the parking orbit radius and whose apogee is twice the lunar distance from Earth. This Earth-Moon transfer ellipse can be thought of as rotating with the Earth and containing the launch site until the instant of lift-off. Thereafter the ellipse is fixed in geocentric inertial coordinates. Geometrically it is required that the Moon intersect the transfer ellipse at encounter time which in turn determines the time of launch. To iterate, the plane of the transfer ellipse contains the launch site at launch time and the Moon at encounter time. The geometry in the plane of the transfer ellipse is completed by the parking orbit coast arc which allows the location of the second Agena burn to inject the spacecraft near perigee of the transfer ellipse to obtain maximum payload capabilities. To compensate for the rotation of the Earth, the launch azimuth and parking orbit coast arc are adjusted simultaneously to preserve the required geometrical relations.

The Ranger lunar trajectories characteristically have flight times of the order of 66 hours. This flight time results in a geocentric central angle between injection and lunar encounter of 167 degrees. This places the injection loci nearly opposite to the Earth-Moon direction at encounter. As a result, the latitude of the injection loci changes as the edclination of the Moon at encounter changes; except that they change in an opposite direction, i.e., for positive declinations of the Moon at encounter the injection loci are farthest downrange. For negative declinations of the Moon at encounter the injection loci are nearest the launch site. During a launch period, the latitude of injection during the launch window (through the azimuth range) is almost constant, but it does vary from day to day as a function of the declination of the Moon at encounter.

Due to AMR considerations the maximum allowable launch azimuth sector that can be utilized is 90-114 degrees east of north. The injection loci for all possible launch days from October 1963 to December 1964 are shown in Figures A-2 to A-17. More detailed analysis is included for typical launch days in the illustrations contained in Appendix C.

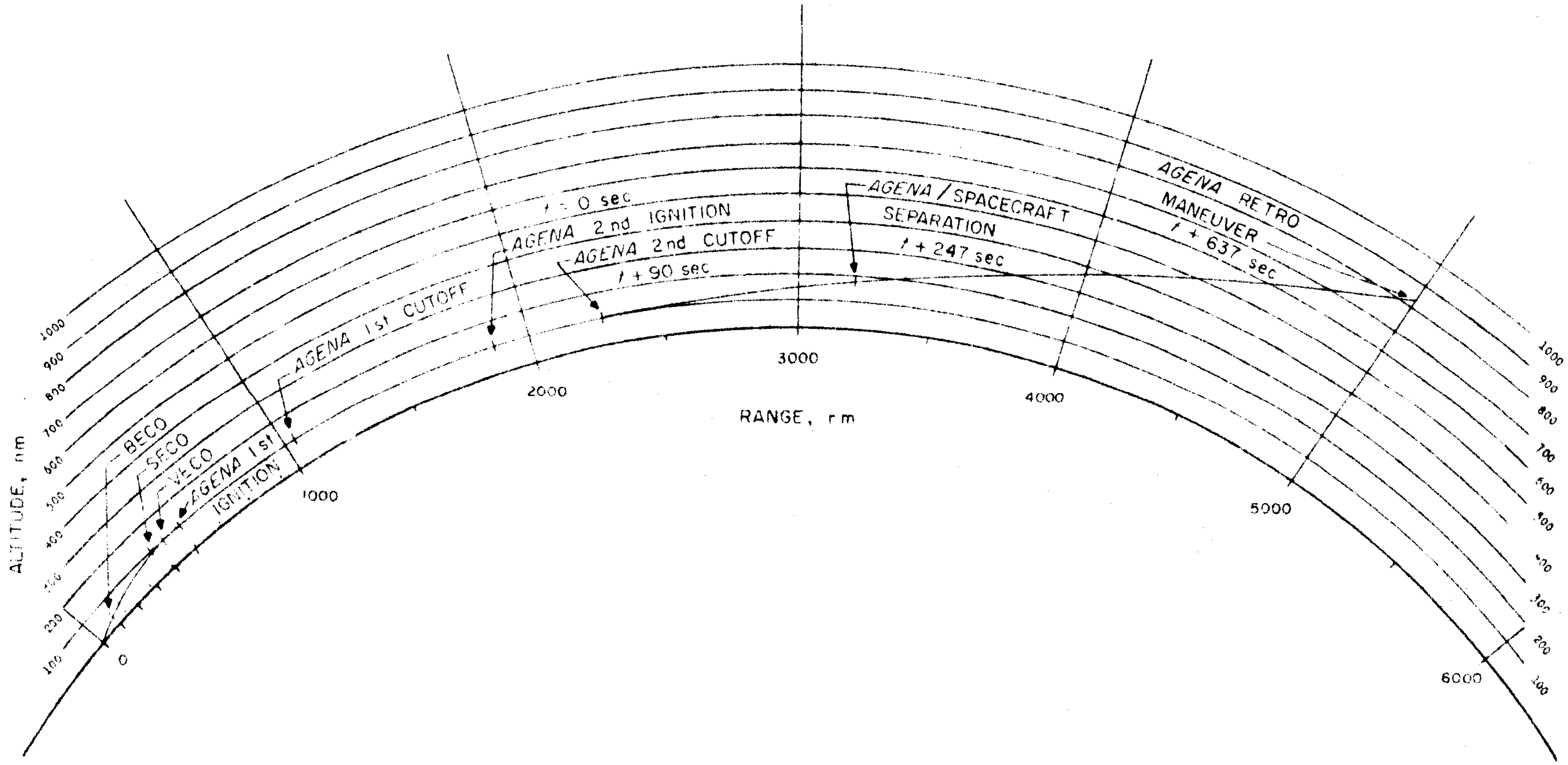


Fig. A-1. Typical Atlas/Agena/Ranger Powered Flight Profile

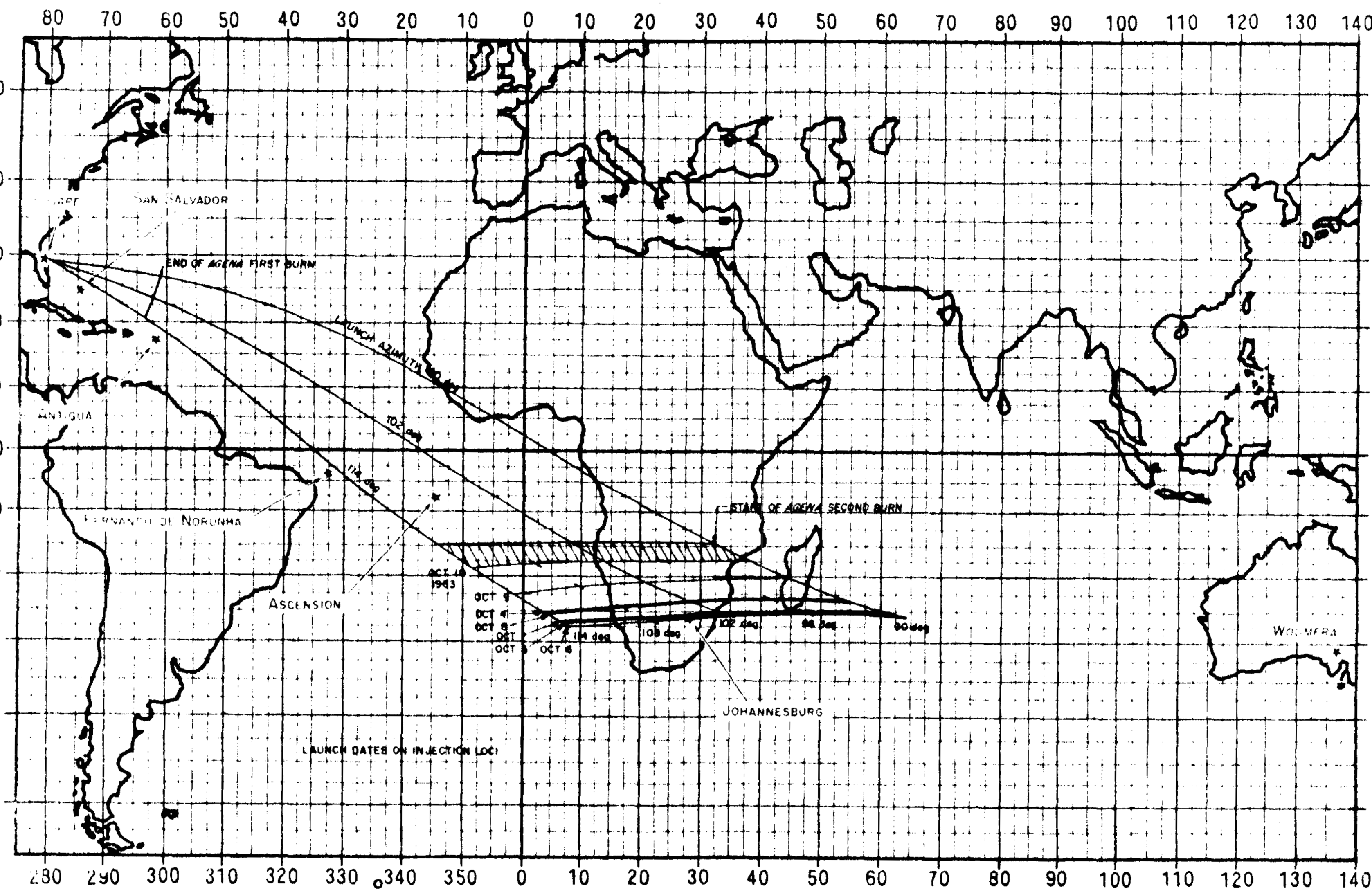


Fig. A-2. Ranger Injection Loci for Oct. 4 through Oct. 10, 1963

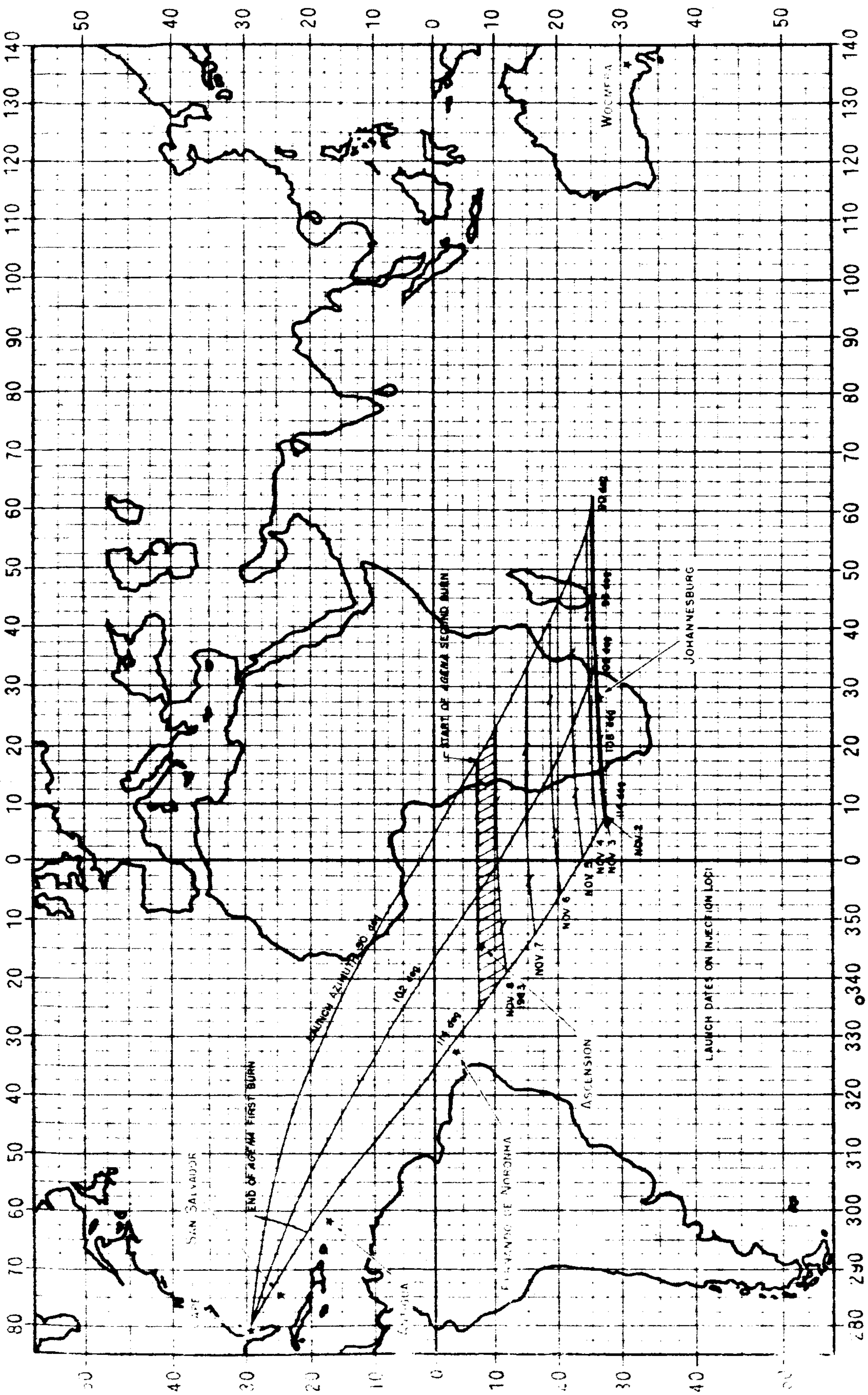


Fig. A-3 Ranger Injection Loci for Nov. 2 through Nov. 8, 1963

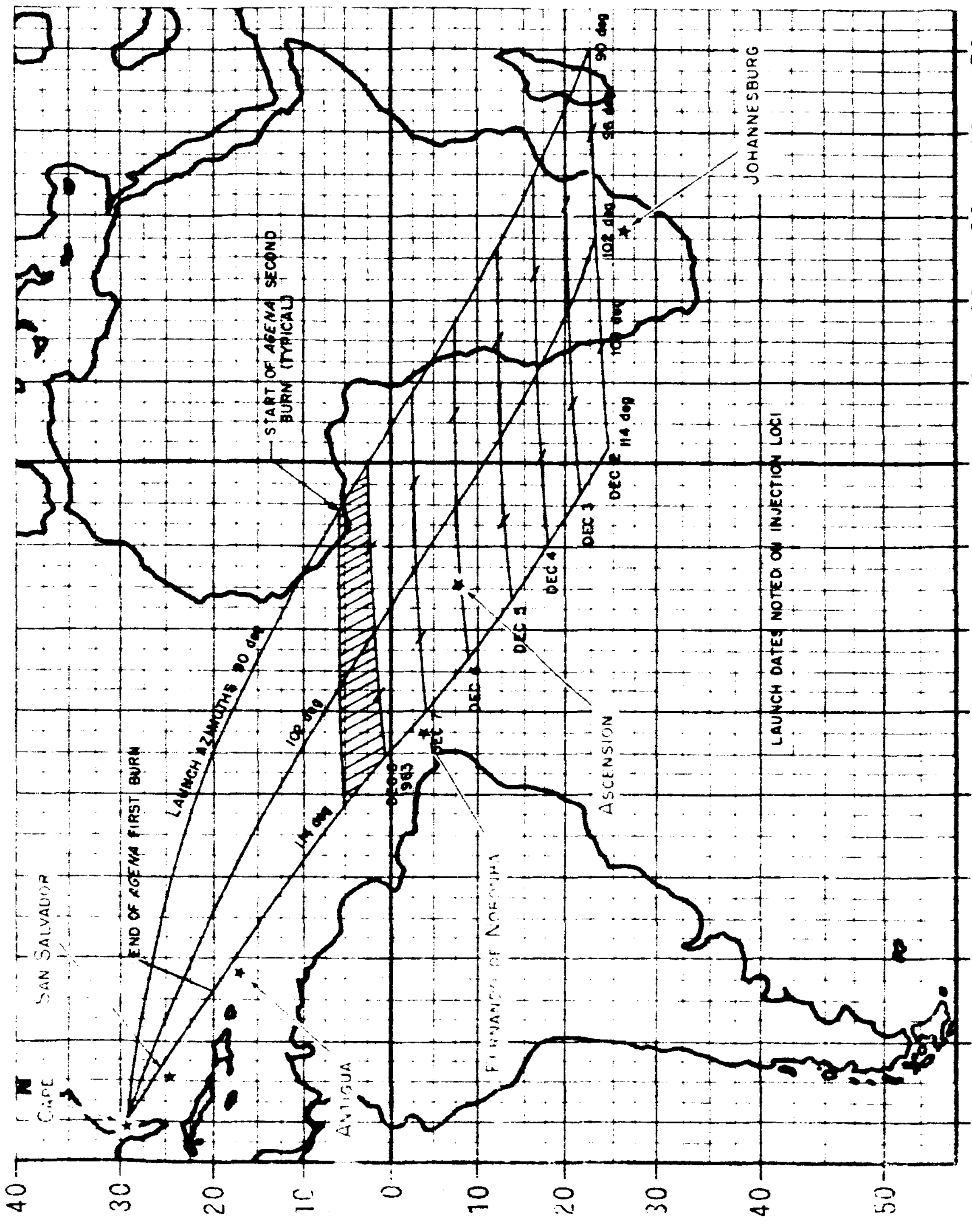


Fig. A-4. Ranger Injection Loci for Dec. 2 through Dec. 8, 1963

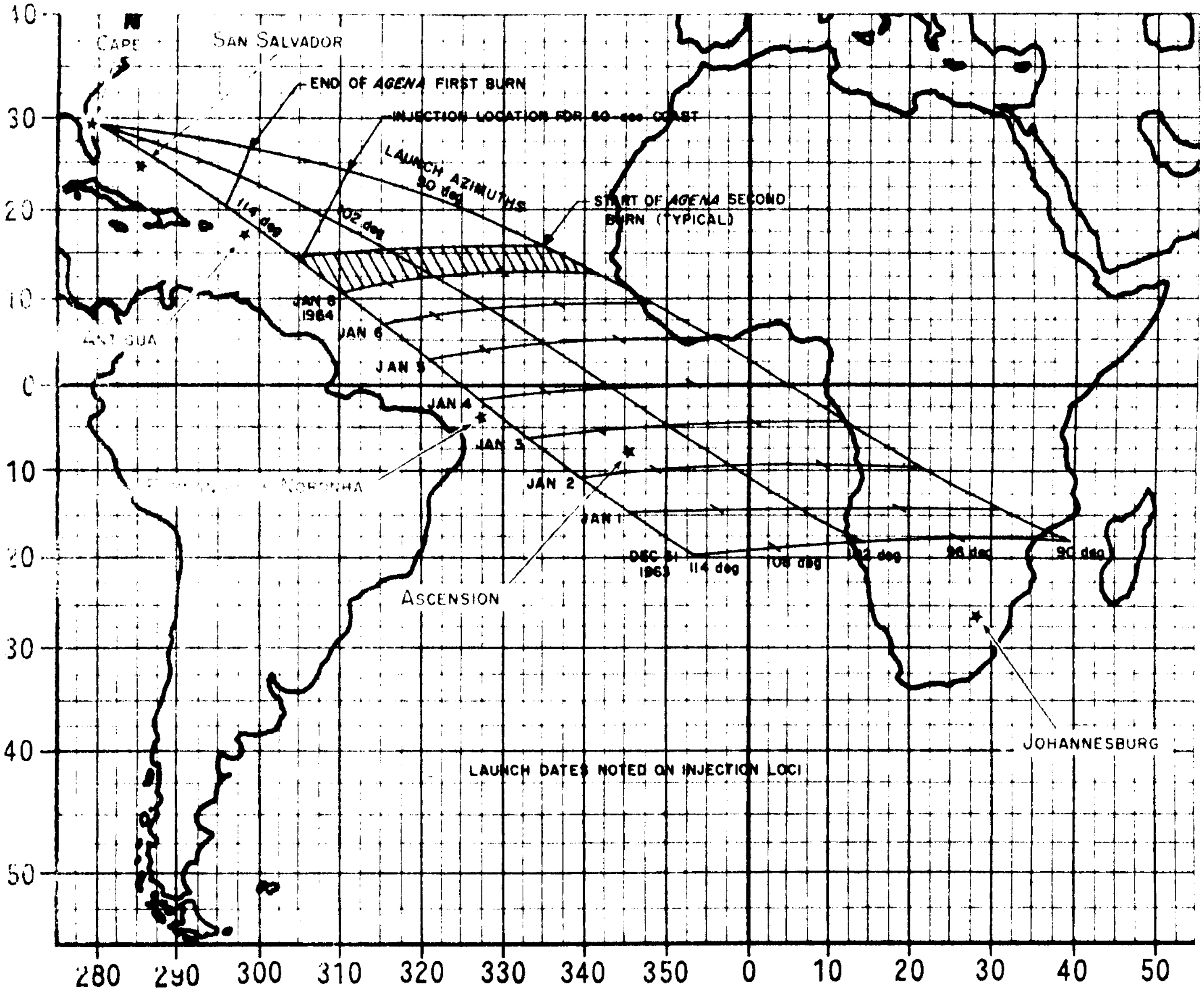


Fig. A-5 Ranger Injection Loci for Dec. 31, 1963 through Jan. 8, 1964

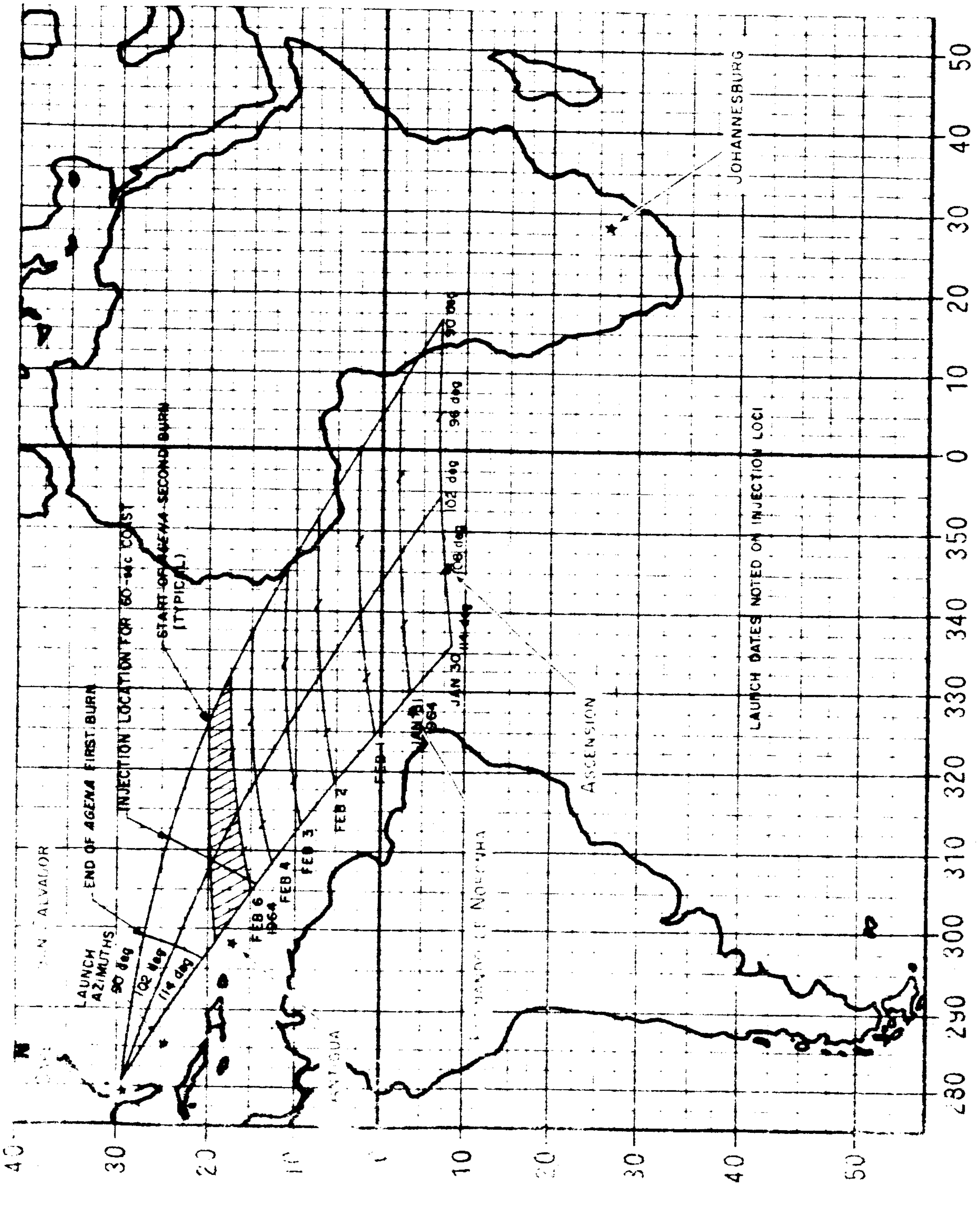


Fig. A-6. Ranger Injection Loci for Jan. 30 through Feb. 6, 1964

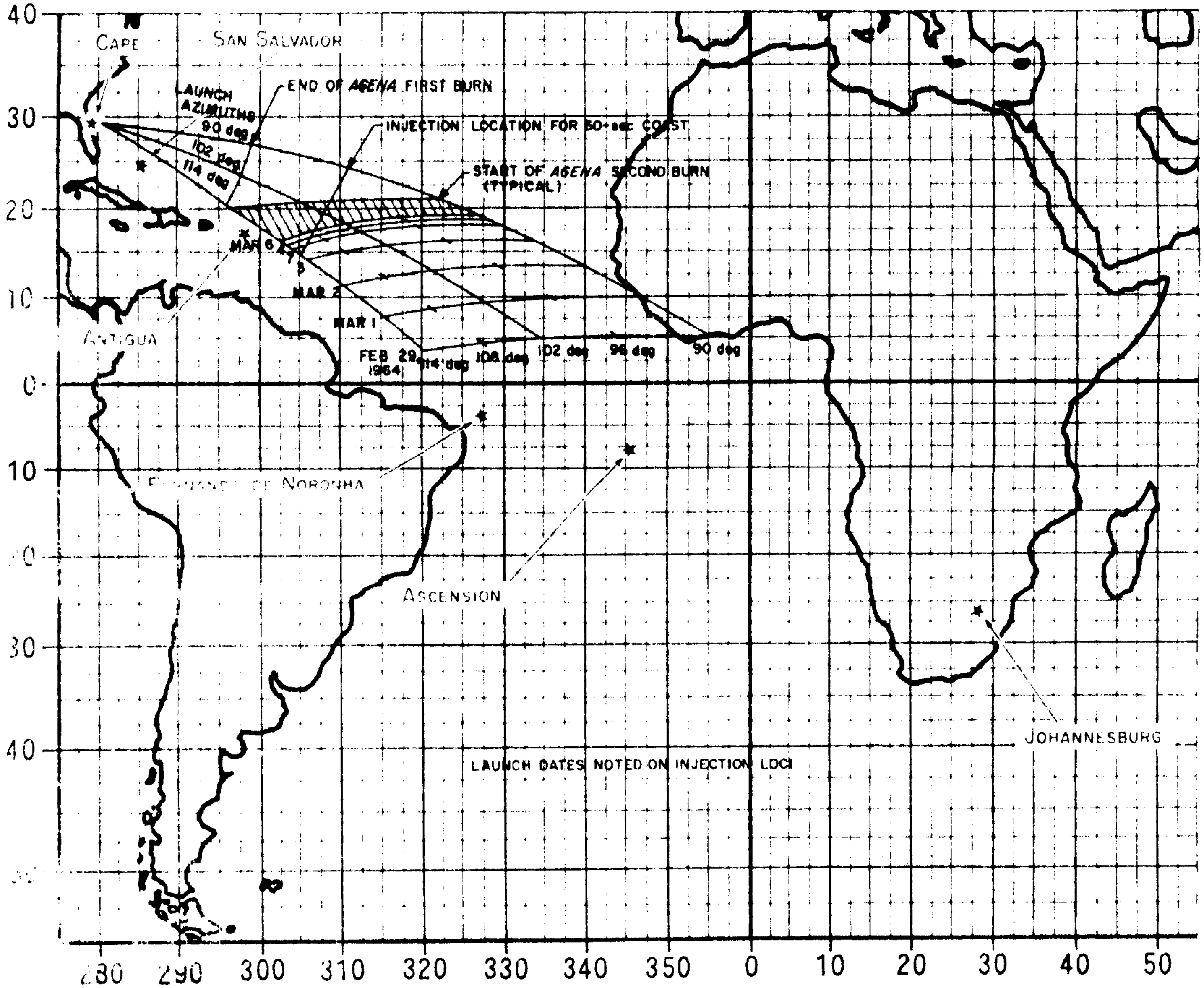


Fig. A-7. Ranger Injection Loci for Feb. 29 through Mar. 7, 1964

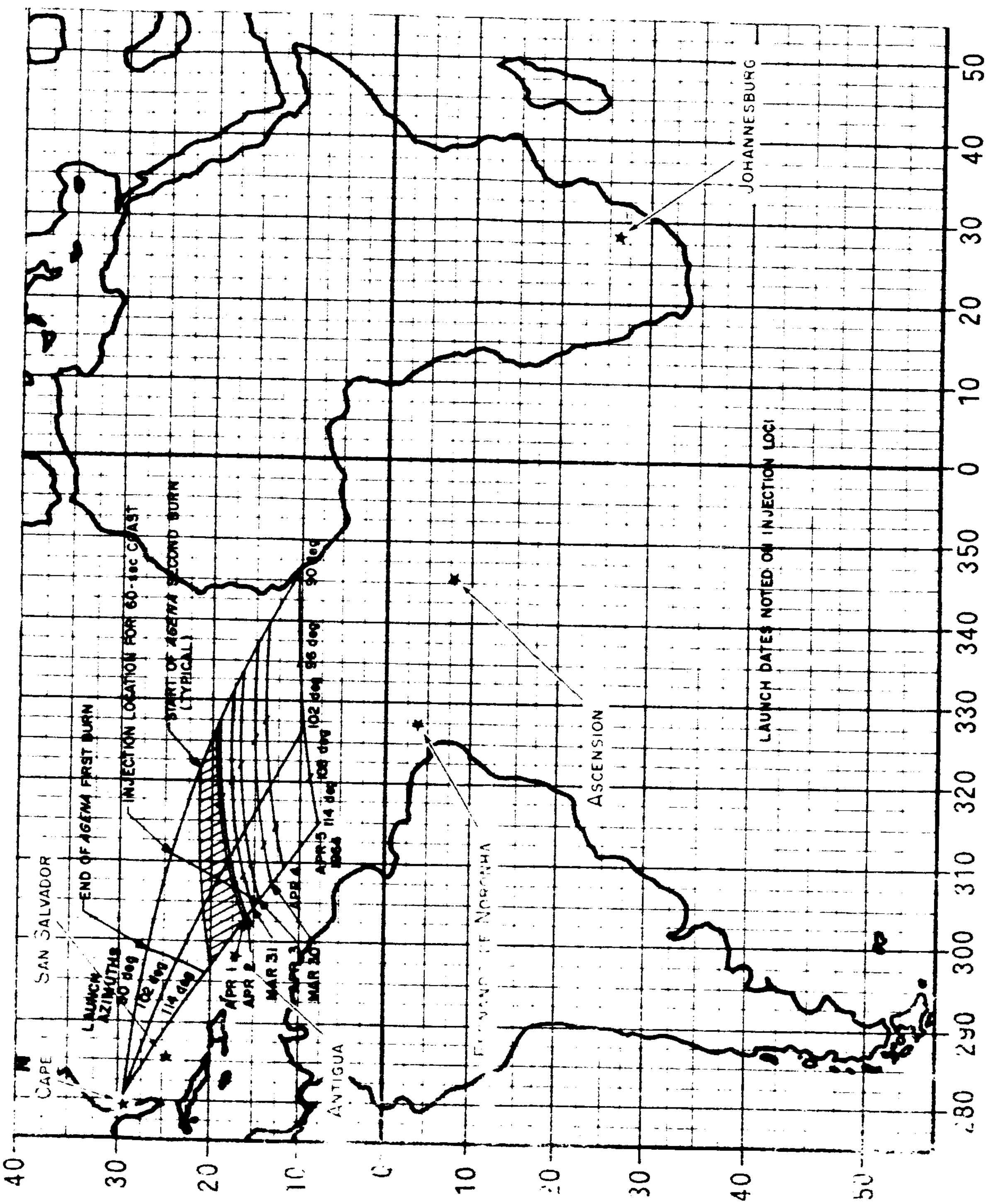


Fig. A-8. Ranger Injection Loci for Mar. 30 through Apr. 5, 1964

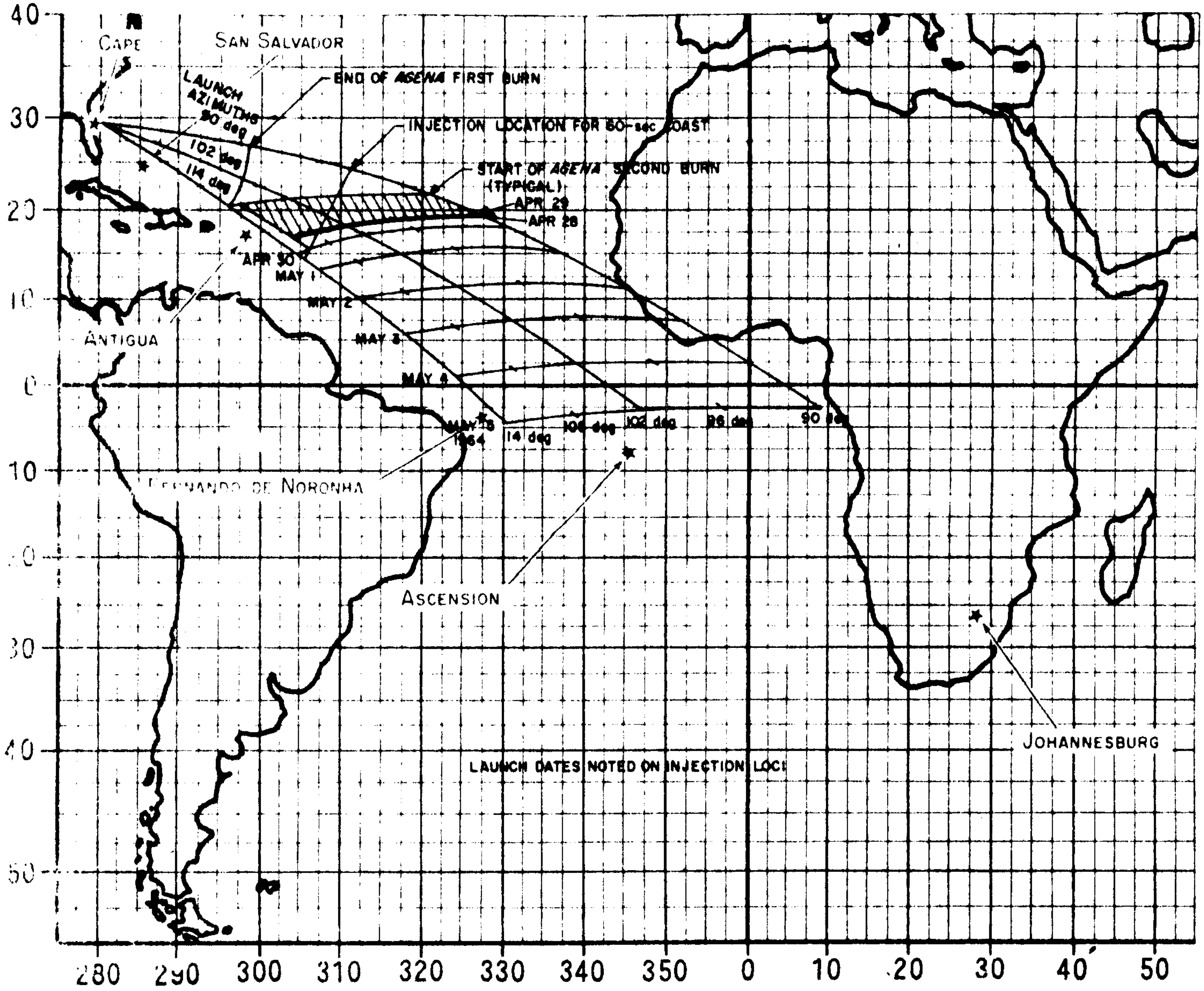


Fig. A-9. Ranger Injection Loci for Apr. 28 through May 5, 1964

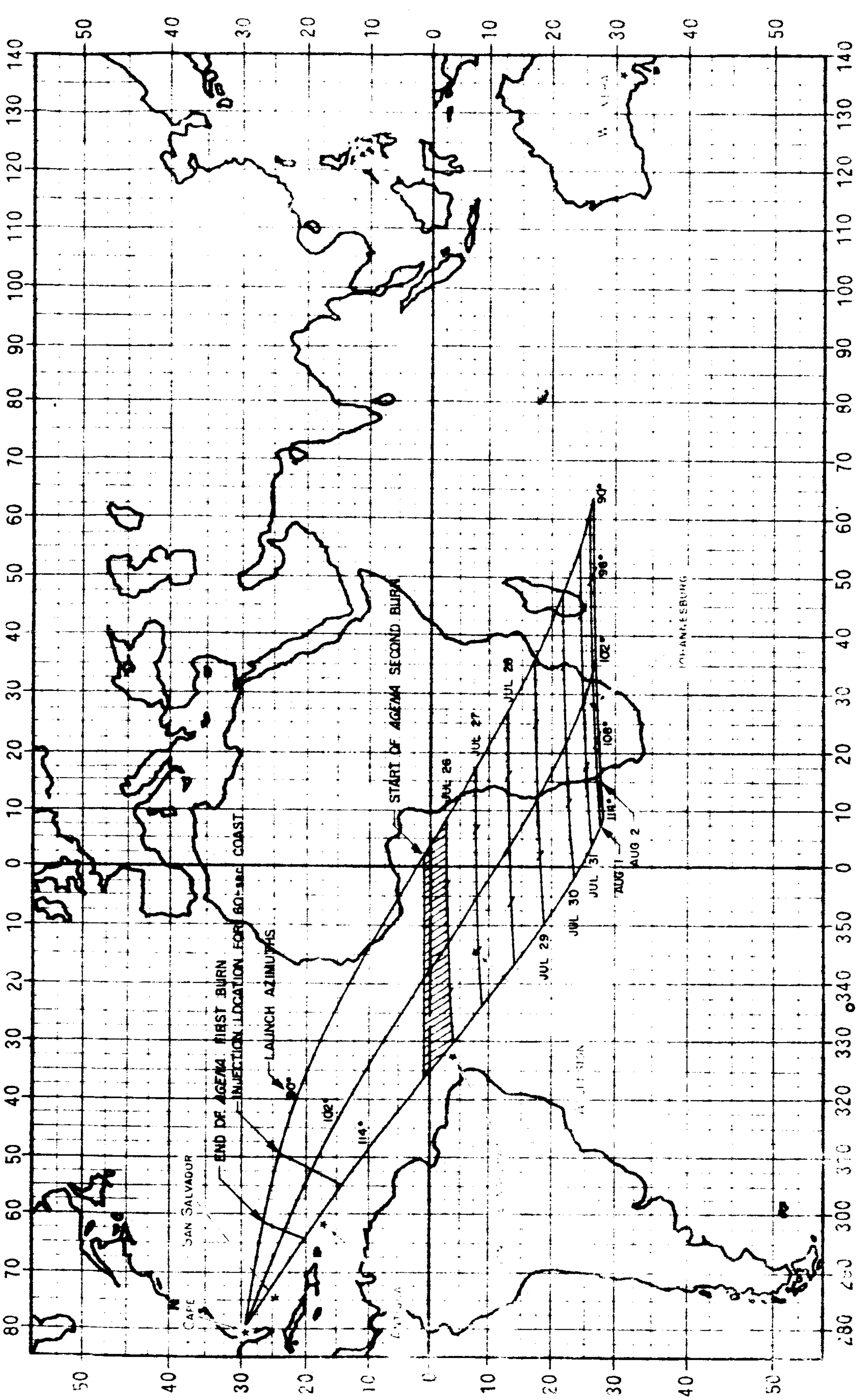
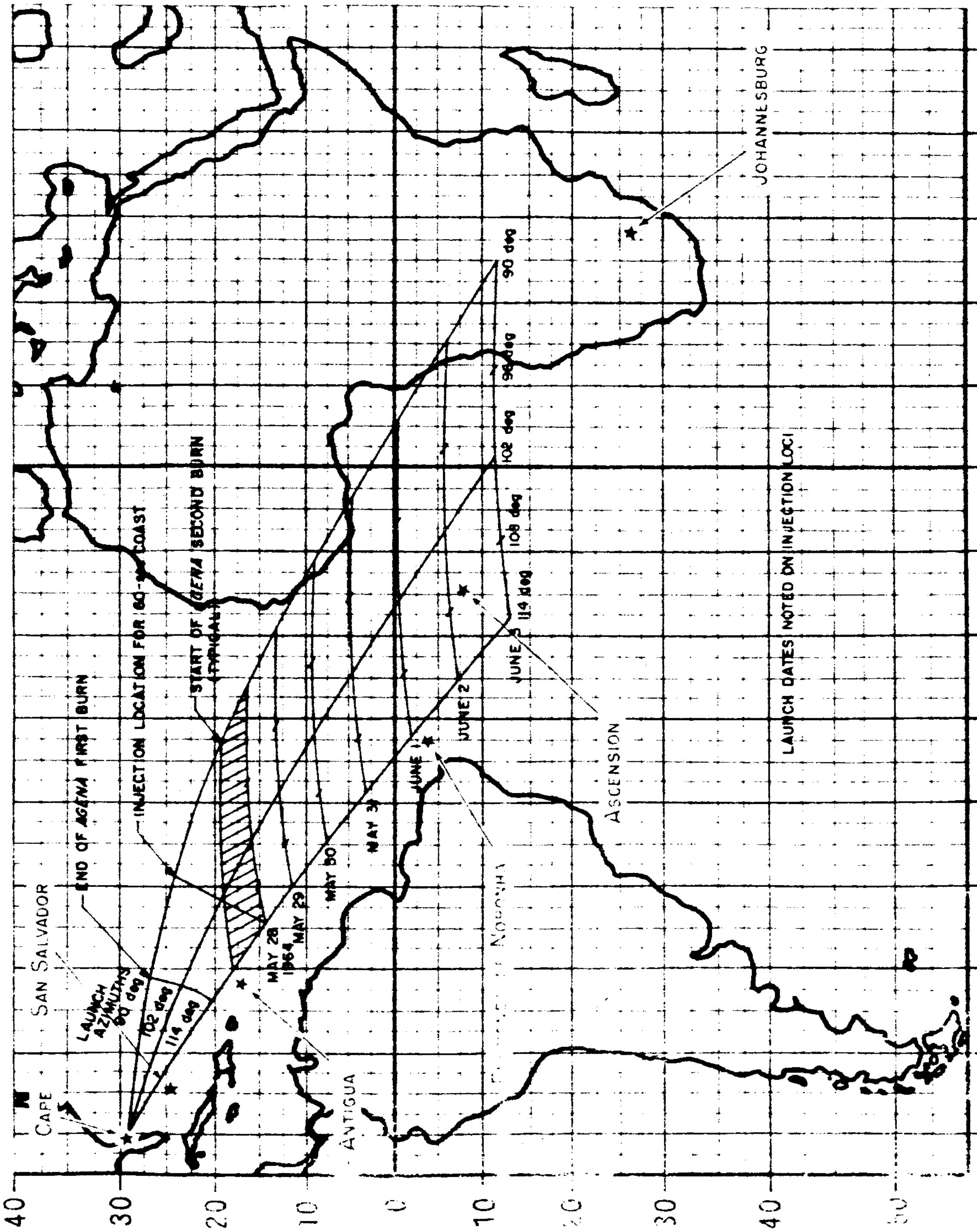
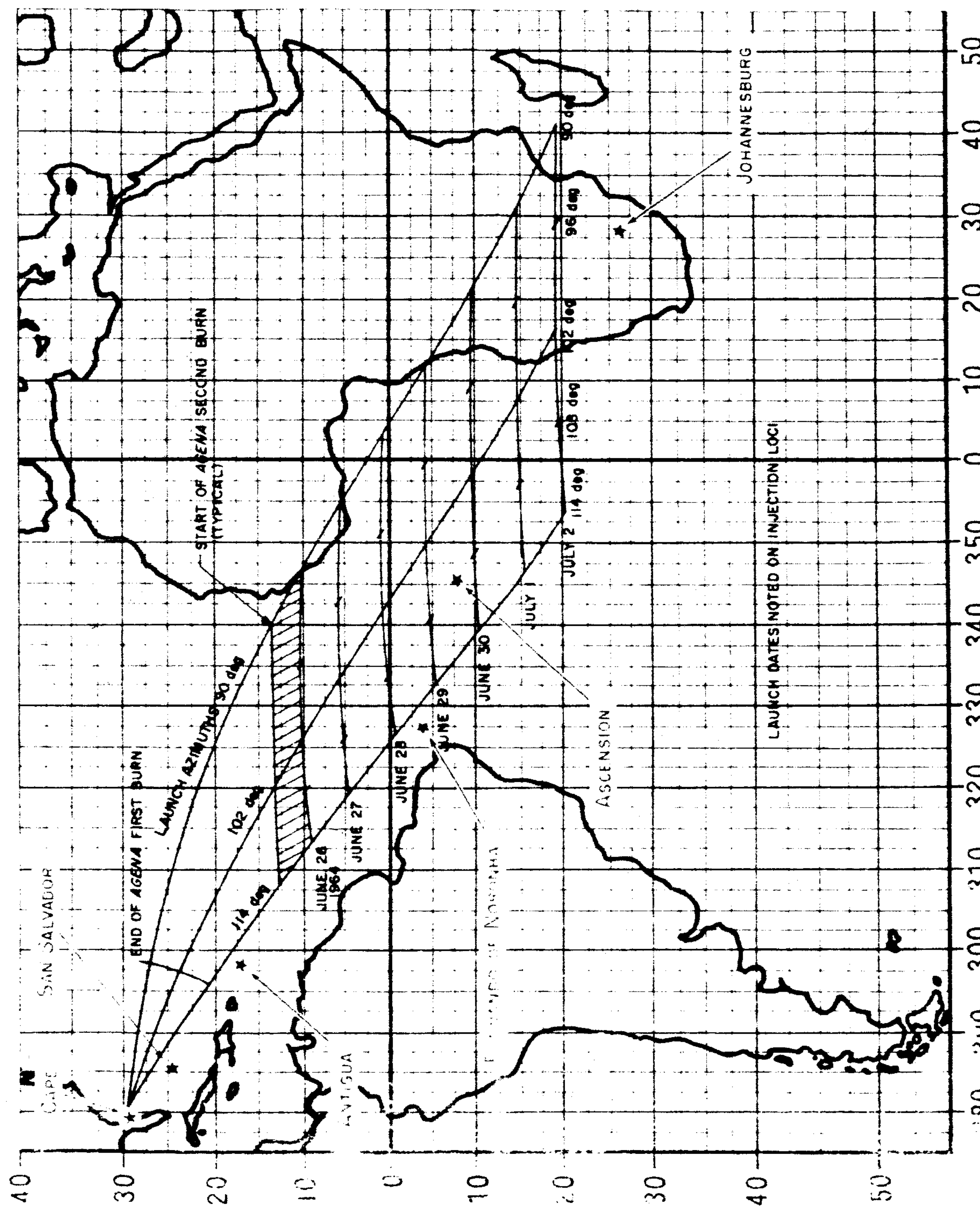


Fig. A-12. Ranger Injection Loci for July 26 through Aug. 2, 1964


CAPE
SAN SALVADOR
ANTIGUA
ASCENSION
JOHANNESBURG
LAUNCH AZIMUTHS 90 deg
102 deg
114 deg
END OF AGENA FIRST BURN
START OF AGENA SECOND BURN (TYPICAL)
MAY 28 1964
MAY 29
MAY 30
MAY 31
JUNE 1
JUNE 2
JUNE 3
90 deg
96 deg
102 deg
108 deg
114 deg
LAUNCH DATES NOTED ON INJECTION LOCI


JOHANNESBURG
START OF AGENA SECOND BURN (TYPICAL)
LAUNCH DATES NOTED ON INJECTION LOCI
ASCENSION
END OF AGENA FIRST BURN
LAUNCH AZIMUTHS 90 deg
102 deg
114 deg
JUNE 26 1964
JUNE 27
JUNE 28
JUNE 29
JUNE 30
JULY 1
JULY 2
114 deg
108 deg
102 deg
96 deg
90 deg
SAN SALVADOR
CAPE
ANTIGUA
40
30
20
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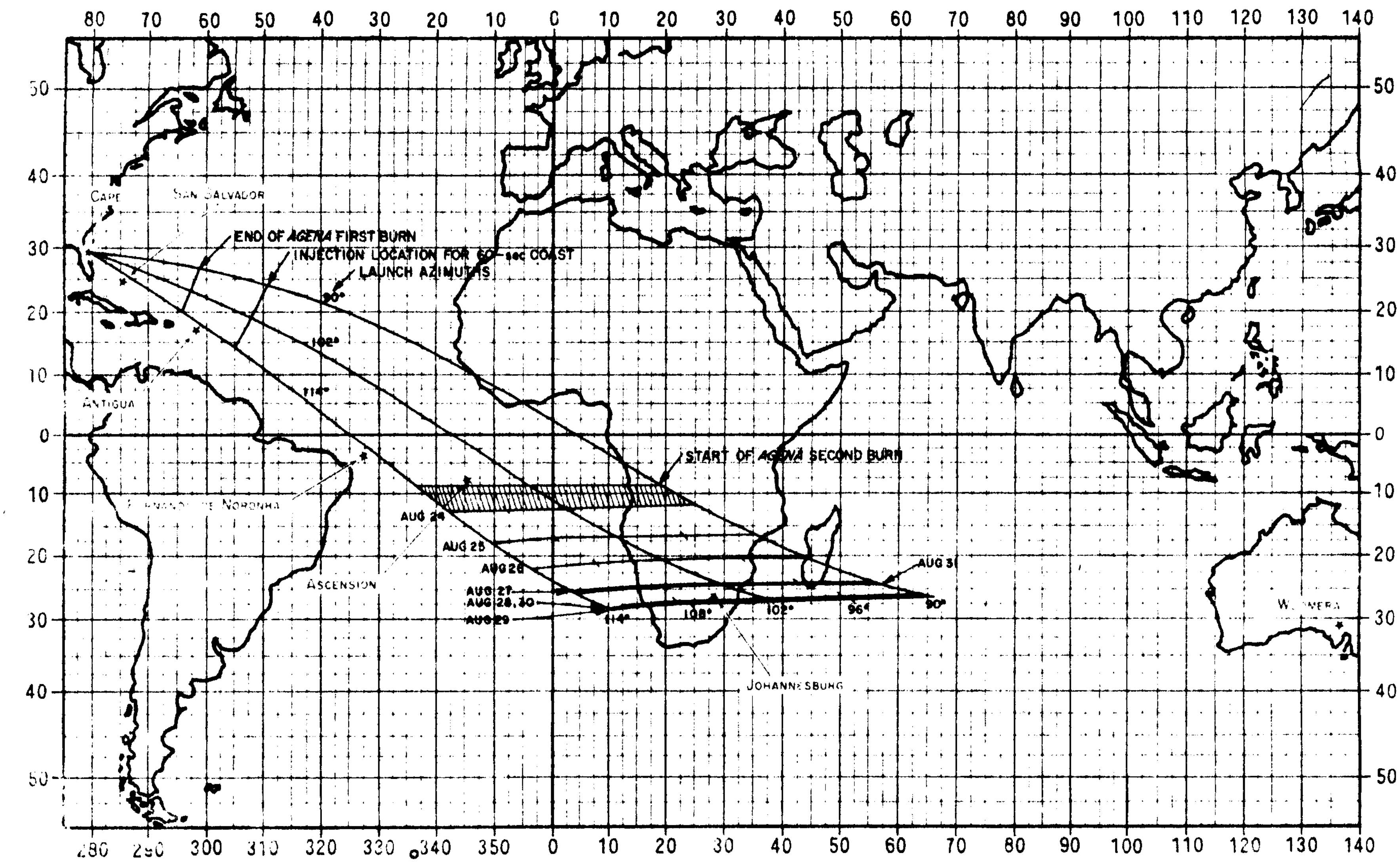

Fig. A-13. Ranger Injection Loci for Aug. 24 through Aug. 31, 1964

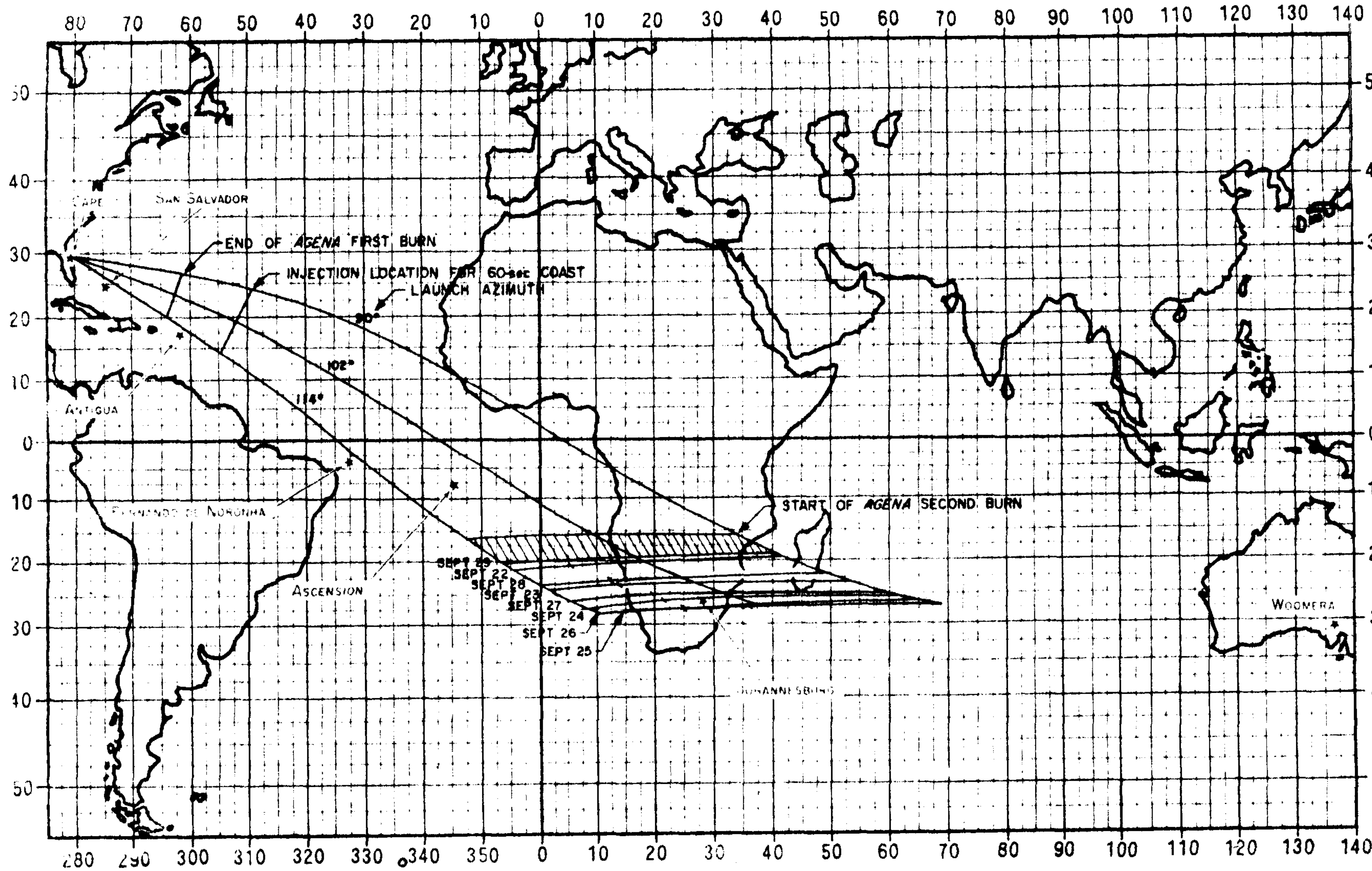

Fig. A-14. Ranger Injection Loci for Sept. 22 through Sept. 29, 1964

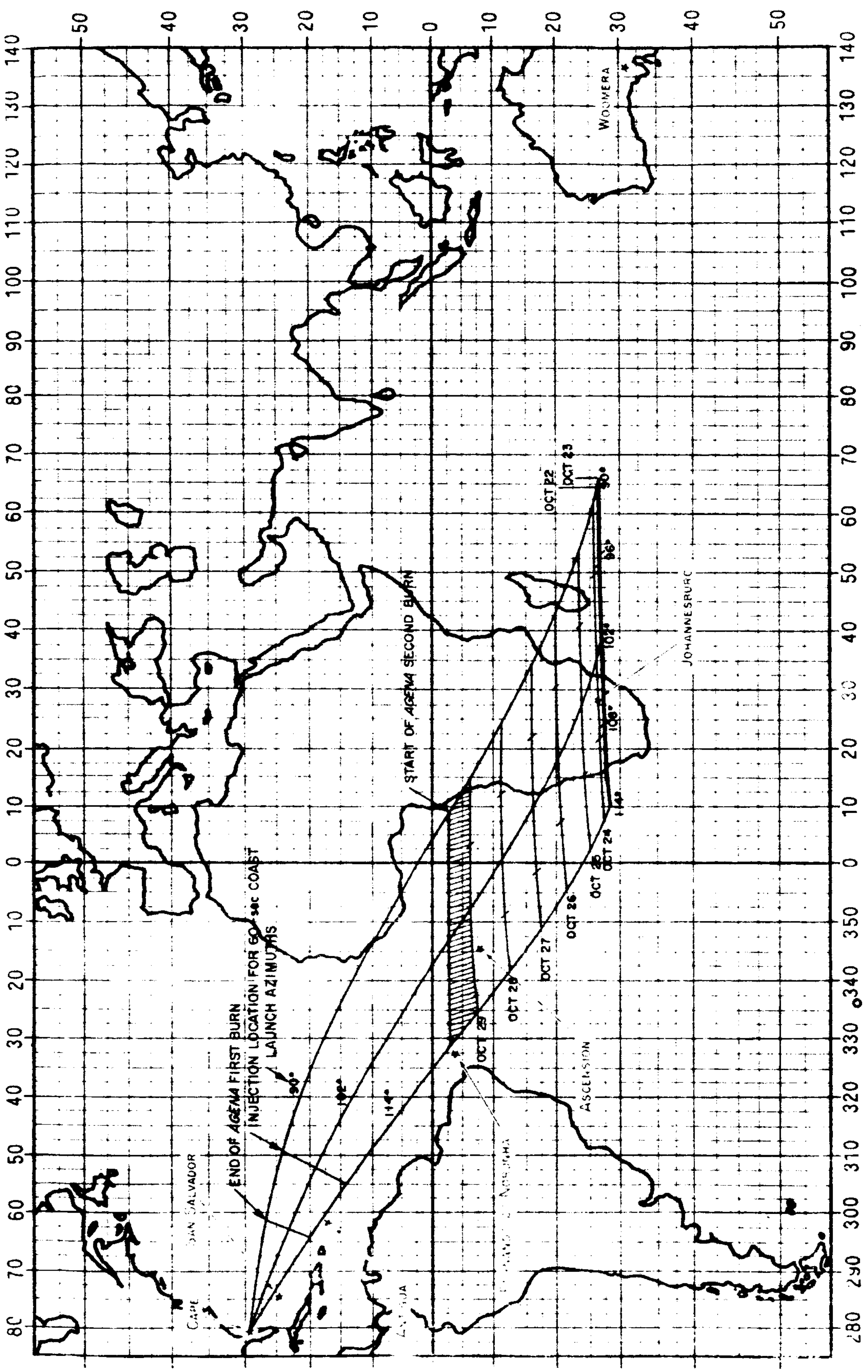

Fig. A-15. Ranger Injection Loci for Oct. 22 through Oct. 29, 1964

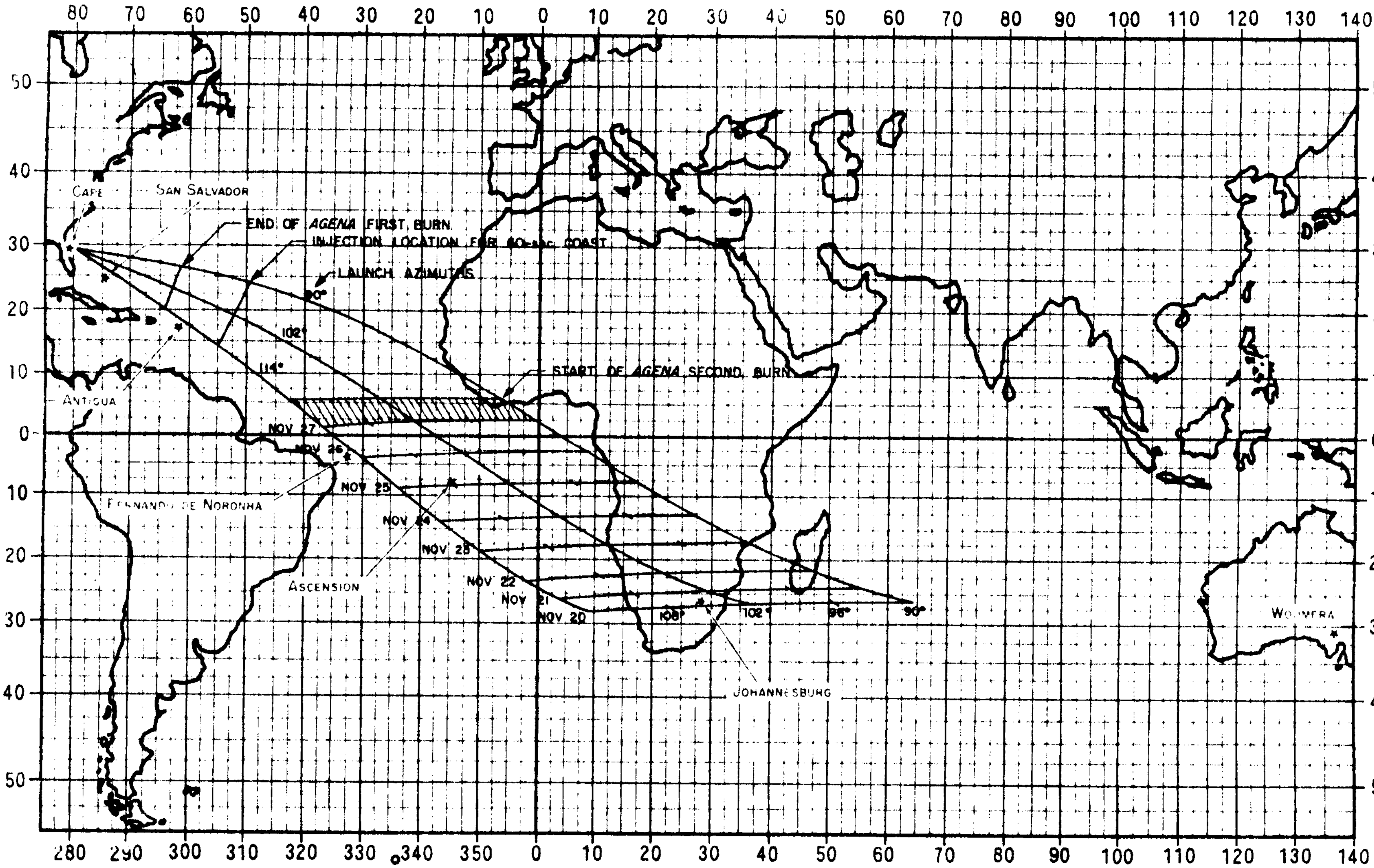

Fig. A-16. Ranger Injection Loci for Nov. 20 through Nov. 27, 1964

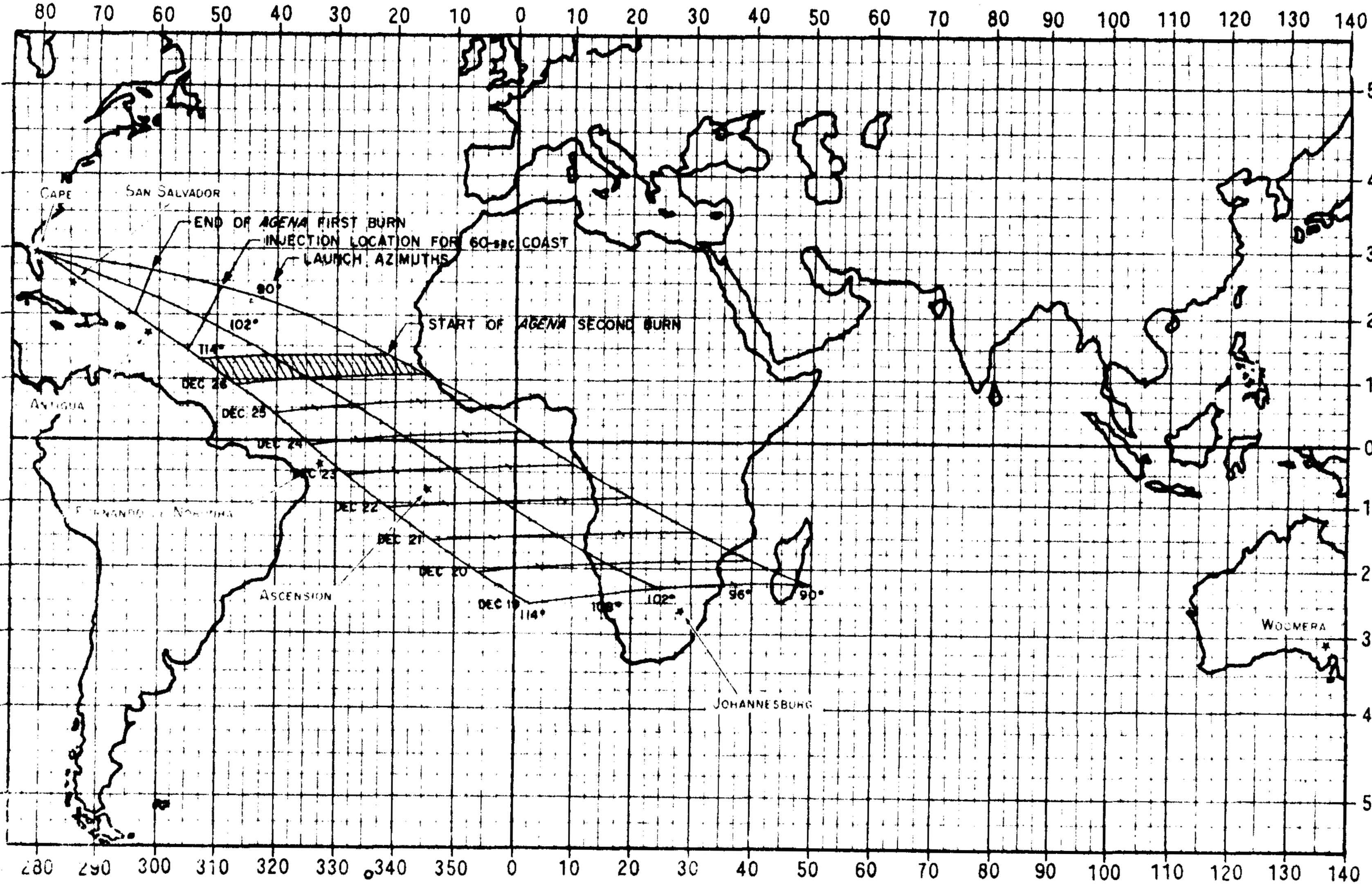

Fig. A-17. Ranger Injection Loci for Dec. 19 through Dec. 26, 1964

APPENDIX B. Requirements for Tracking and Telemetry Coverage

I. INTRODUCTION

The purpose of this appendix is to describe in detail the tracking and telemetry coverage requirements that result as a consequence of the Ranger Block III missions. Basically, three categories of requirements exist: (1) the technical data and support required by the tracking and telemetry facilities (AMR and DSIF) and needed to meet their mission commitments; (2) tracking coverage required of AMR and DSIF; and (3) telemetry coverage required of AMR and DSIF.

AMR and DSIF have certain requirements comprising category (1) above. These requirements must be met and certain limitations of AMR and DSIF capabilities observed in order that AMR and DSIF can, in turn, support the requirements placed upon them. These requirements and capability limitations are described in Paragraph III.

The tracking and telemetry coverage requirements placed upon AMR and DSIF are treated in Paragraphs IV and V. These requirements originate from the four following areas:

(1) Ranger Block III Mission Requirements

The mission requirements are placed on the AMR and the DSIF by the Ranger Project, JPL, Pasadena, California

(2) SLV-III (Atlas D) Booster Requirements

The Atlas booster requirements are, in most instances, independent of the payload. These requirements are placed on the AMR by the 6555th Aerospace Test Wing, PAFB, Florida.

(3) S-01 (Agena B) Booster Requirements

The Agena vehicle requirements are, in most instances, independent of the payload. These requirements are placed on the AMR by the Agena System, LeRC, Cleveland, Ohio.

(4) AMR Range Safety

The Range Safety requirements are placed by the Deputy for Range Operations.

Requirements placed on the AMR, defined in items (1) and (3) above, are placed through the NASA Test Support Office (NTSO). Requirements placed on the AMR, defined in items (1), (2), and (3) are specified in the appropriate Booster Requirements Document (BRD) and Program Requirements Document (PRD). Requirements placed on the DSIF are specified in the appropriate Space Flight Operations Plan (SFOP). Range Safety requirements are placed on the AFMTC through a system internal to the range.

The requirements for tracking and telemetry coverage are placed in accord with their importance to the successful accomplishment of the mission and are segregated into classes; i.e., Class I Requirements, Class II Requirements, and Class III Requirements. These class designations are used extensively by AMR and are defined in Paragraph II.

Paragraph IV of this appendix develops the tracking coverage requirements in the following manner:

(1) The mission requirements state that the spacecraft must impact the Moon at the desired aiming point at the desired time within a certain accuracy tolerance.

(2) A midcourse maneuver will be used, if necessary, to correct trajectory errors at injection.

(3) Therefore, a requirement for orbit determination accuracy prior to the midcourse will be placed so that the subsequent maneuver can meet the mission accuracy requirements at lunar impact.

(4) The tracking coverage, data interval and data accuracy requirements will then be placed on the AMR and DSIF to support the orbit determination accuracy requirements.

Paragraph V of this appendix develops the telemetry coverage requirements in a similar fashion to that employed in Paragraph IV.

II. DEFINITION OF CLASSES I, II, AND III REQUIREMENTS

Requirements for tracking and telemetry coverage are placed according to their importance as either Class I, II, or III. These Classes are defined by AMR as follows:

"Class I requirements reflect the minimum essential needs to insure accomplishment of primary test objectives.

These are mandatory requirements which, if not met, may result in a decision not to launch.

Class II requirements define the needs to accomplish all stated test objectives.

Class III requirements define the ultimate in desired support. Such support should enable the Range User to achieve the test objectives earlier in the test program."

Some additional discussion of the three classes is appropriate here.

Class I JPL missions have consistently honored this requirement. No JPL launches have ever taken place in which Class I requirements could not be met. It is highly desirable to continue this policy.

Class II These requirements are desirable but the lack of Class II coverage does not constitute grounds for a hold of the launch.

Class III A corollary to Class III capability is as follows: "The value of support capability in excess of Class III capability will not be significantly higher than the value of the Class III capability itself."

III. AMR AND DSIF REQUIREMENTS

A. AMR Requirements

The AMR requirements must be met so that it can, in turn, support the requirements placed on it for tracking and telemetry coverage. These AMR requirements are defined below.

1. Trajectory data

   a. Prelaunch

   Trajectory data must be provided to AMR six (6) weeks prior to the launch. These data are processed by the AMR to obtain range safety information (see Appendix D) and nominal look angles for AMR tracking stations. These trajectory data are provided by Space Technology Laboratories (STL) under subcontract to Lockheed Missiles and Space Company (LMSC). The preparation of these data is well controlled by schedules and the Agena Lunar Performance Panel monitors this activity at all times. When these data are provided as scheduled, they will not cause any constraint to the launch.

b. Inflight

AMR generates inflight prediction data for acquisition by downrange tracking stations. These inflight messages are based on uprange tracking. Heretofore, there have been no launch constraints due to inadequate uprange tracking. (However, uprange tracking from the AMR land stations is marginal during the beginning of any launch window i.e., 90-96 degrees.) Therefore, there is, currently, no launch constraint due to inadequate uprange tracking in the azimuth sector between 90-114 degrees.

2. Communications

AMR requires communications with the range tracking stations. However, if the range is functioning as designed, the communications system is adequate and does not constrain a launch. A possible exception is a state of RF "blackout"between a station and the Cape. Such an occurrence (only occasionally predictable) may cause a hold.

B. DSIF Requirements

The DSIF requirements must be met so it can, in turn, support the requirements placed on it for tracking and telemetry coverage.

The DSIF is not designed to provide a tracking capability during the parking orbit and near-Earth phase of the trajectory. Several DSIF requirements must be met to allow the DSIF to provide tracking and telemetry coverage during this early pre- and post-injection phase.

1. Spacecraft Telemetry Calibration

Telemetry calibrations of the spacecraft's received AGC and SPE for each of the spacecraft the DSIF must track must be available at the station in insure proper two-way acquisition. (A corollary is that the appropriate ground telemetry equipment must be functioning. Telemetry equipment which is "down" at a station required to provide Class I tracking coverage constitutes grounds for a launch hold.)

2. Data Required for Acquisition

The following requirements must be met to enable prompt acquisition of the spacecraft signal:

(a) For reliable acquisition, first acquisition predictions to the DSIF should be available at SFOF at least ten (10) minutes before "first look". However, predicts will be useful up to 10 minutes before end of station view.

(b) Angles (HA-Dec) - Accuracy: to at least ±3 degrees for first acquisition and within ±0.2 degrees thereafter.

(c) One-way doppler frequency - Accuracy: within 100 cps at the signal frequency and tagged so it will be possible to relate time to frequency (actual) within n seconds of each 1/n Kc of frequency shift per second.

(d) Two-way doppler frequency - Accuracy: within 100 cps at the signal frequency and tagged so it will be possible to relate time to frequency (actual) within n seconds of each 1/n Kc of frequency shift per second.

(e) Transmitter frequency predicts - Accuracy: to the nearest 5 cps at the signal frequency and time tagged within 10 seconds of actual.

(f) Spacecraft transponder data as validated at launch (L-5 minutes) for the following:

(1) Ancillary oscillator frequency

(2) Ground transmitter at zero spacecraft static phase error (SPE)

(3) Spacecraft transmitter at zero spacecraft SPE

(4) Ground transmitter frequency corresponding to the average no-signal transponder SPE volts.

(g) Data interval for prediction messages will be chosen on an individual basis for each mission. A typical choice could be one (1) line per two (2) minutes for the first hour and one (1) line per five (5) minutes from one (1) to three (3) hours.

3. Additional Requirement

The DSIF 85-foot antennas have several requirements relating to station capabilities. It is a requirement that the maximum capabilities listed below are not exceeded:

(a) One-Way Doppler:

(1) Frequency tuning range ±30 Kc (maximum doppler shift)

(2) Loop noise bandwidth 20-60 cps at threshold (switchable).

(3) Possible frequency rate ($\dot{f}$) vs signal level for various noise bandwidths. (These data will be provided in the next issue of this document.)

(4) Acquisition time versus $\dot{f}$ versus quality of prediction data. (These data will be provided in the next issue of this document.)

(b) Two-Way Doppler:

(1) Same as (a.1.) above. (Note that this is one-half (1/2) of the velocity range covered by one-way doppler. Adjacent channel coverage will not normally be supplied unless requested.)

(2) Loop noise bandwidth - same as (a,2) above.

(3) Possible $\dot{f}$ versus signal level for various noise bandwidths. Acquisition at rates greater than 50 cps/second will be virtually impossible. (These data will be provided in the next issue of this document.)

(4) Frequency rate ($\dot{f}$) restrictions on combinations of doppler and transmitter VCO search rates. (These data will be provided in the next issue of this document.)

(5) Acquisition time versus $\dot{f}$ versus quality of prediction data. (These data will be provided in the next issue of this document.)

(c) Angle Tracking:

(1) For reliable acquisition, tracking rate should not exceed 0.4 degrees per second. System maximum rate is 0.7 degrees per second.

(2) Multipath Problems

(a) Acquisition antenna, angle tracking data is accurate to about 0.5 degrees. However the multipath effect will result in poor angle data at elevation angles of less than 10 degrees.

(b) Big Dish. Angle data is accurate to about 0.1 degrees. However, the multipath effect will result in poor angle data at elevation angles of less than 2 degrees.

The DSIF Mobile Tracking Station in South Africa has maximum capabilities as follows:

(1) One-way doppler. Same as 85-foot dishes

(2) Two-way doppler. Same as 85-foot dishes

(3) Angle tracking. Tracking rate should not exceed 20 degrees per second.

4. Summary of DSIF Requirements

This paragraph is a summary of the two preceding paragraph B.2. and B.3. Its purpose is to present to those not aquainted with the complexities of the RF system a clearer picture of the limitations imposed on the trajectory.

The DSIF requirements stem from the antenna limitations in the following two areas:

(a) Angles:

The 85-foot antennas have a maximum angle rate of 0.7 degrees per second on each axis. At South Africa, however, the Mobile Tracking Station has a maximum angle rate of 20 degrees per second.

(b) Doppler:

The system can accommodate a doppler shift of ±30 Kc without retuning. This corresponds to a slant range rate, $\dot{r}$, of approximately 9 km/sec. It should be pointed out that the possibility of retuning during the launch phase is highly impractical. The maximum doppler rate of the system is ±3 Kc/sec^2 which corresponds to a slant range acceleration, $\ddot{r}$, of 0.5 km/sec^2.

Furthermore the DSIF antennas require a nominal acquisition time of ~2 minutes. For this reason and because short view periods usually result in high angle and doppler rates, the DSIF is not committed for view periods of less than 5 minutes.

IV. TRACKING COVERAGE REQUIREMENTS

A. Introduction

The requirements for tracking coverage to be supplied by AMR and by the DSIF are developed in the following manner:

(1) Those premidcourse orbit determination accuracy requirements that affect both AMR and DSIF are developed in subparagraph B, following.

(2) The data accuracy and coverage requirements placed upon AMR are specified in Subparagraph C, following.

(3) The data accuracy and coverage requirements placed upon the DSIF are specified in Subparagraph D, following.

B. Orbit Determination Accuracy Requirements

In order to satisfy the Ranger mission objectives, the guidance dispersions at the Moon must be held within certain limits. These dispersions arise from three causes:

(1) Errors in orbit determination due to noisy data and uncertainties in physical and observational constants.

(2) Errors in executing the commanded maneuver

(3) Unpredictable trajectory perturbations occurring after the maneuver caused by solar storms, attitude jets, etc.

The requirements for allowable errors due to the conditions stated in B (1) above are specified by classes in the following text. These requirements are summarized in Table B-I, Part I.

1. Class I Requirements

The semi-major axis of the 1-σ error ellipse shall not be greater than 150 km on the final premidcourse maneuver orbit using tracking data available up to seven (7) hours before the first Goldstone Set.

a. Accuracy

Based upon the best estimates of the Space Sciences Division to data, the primary test objectives can be met only if impact occurs between 10 and 40° from the terminator. If the

Table B-1. Spacecraft Tracking Coverage Required of DSIF
(Requirements placed by JPL)

PART I

Ranger Block III Orbit Determination Accuracy Requirements

Class	Orbit Determination Accuracy Requirements
I	Using all data to Goldstone set - 7 hours: $1\text{-}\sigma$ SMAA $\leq$ 150 km
II	(1) Using all data to Johannesburg set - 7 hours: (approximately L + 4^h): $1\text{-}\sigma$ SMAA $\leq$ 150 km
	(2) Using all data to Goldstone set - 7 hours: $1\text{-}\sigma$ SMAA $\leq$ 30 km
III	Using all data to Goldstone set - 7 hours: $1\text{-}\sigma$ SMAA $\leq$ 3 km

PART II

DSIF Tracking Data Accuracy Requirements

	(Effective Noise* at 1 sample per minute)				
	2-way doppler ($1\text{-}\sigma$), cps	Angles ($1\text{-}\sigma$), deg	3-way doppler ($1\text{-}\sigma$), cps	Time synchronization, seconds	Abs. frequency stability over one (1) minute intervals
"Guaranteed" Ranger Block III	0.2	0.18	20.0	0.02	1.0×10^{-8}
Desired, not "guaranteed" Ranger Block III	0.067	0.06	0.5	0.004	3.0×10^{-10}
Ultimate	0.02	0.018	0.15	0.0001	1.0×10^{-10}

*Effective noise accounts for correlations in the data, variations in refraction corrections, oscillator drift, cycle count drops, transmitter variations, etc.

A.L.

Table B-1 (Cont'd)

PART III

Orbit Determination Accuracy Capabilities*

Acquisition time measured from injection, minutes	Semimajor Axis of the 40% Dispersion Ellipse			
	Uprange injection, S. A. is 1st DSIF station to see S/C post-injection		Downrange injection, Woomera is 1st DSIF station to see S/C post-injection	
	Favorable azimuth	Unfavorable azimuth	Favorable azimuth	Unfavorable azimuth
0	15 km	35 km	--	--
5	20	60	--	--
10	50	80	55 km	80 km
15	60	90	70	110
20	70	100	80	130
25	--	--	90	150

*Assumes 5-minute acquisition after rise above 5° horizon, 9 hours of tracking data with no drop outs, both Woomera and South Africa tracking, no AMR data, Class I data accuracy.

PART IV

Required DSIF Stations

Orbit determination accuracy requirement	Required DSIF Stations for Class I and Class II Tracking Coverage	
	Class I	Class II
I	(1) MTS, Woomera, or (2) Joburg, Woomera, or (3) MTS, Goldstone, or (4) Joburg, Goldstone, or (5) Woomera, Goldstone	Class I stations plus one (1) additional station
II (Requirement No. 1)	(1) MTS, Woomera or (2) Joburg, Woomera	MTS, Joburg, Woomera

midcourse maneuver is targeted to 25 degrees from the terminator, an error as large as ±700 km (in the $\overline{R}$-$\overline{T}$ plane) can be tolerated. The requirement to insure the accomplishment of the mission objectives is that the combined 3-σ error ellipse from both orbit determination uncertainties and midcourse execution errors fall entirely inside this permissible interval. The 3-σ error from a full maneuver (60 M/S) may be taken to be 450 km. Therefore, the orbit determination 3-σ error ellipse should have a semimajor axis of not more than 450 km, or a 1-σ value of 150 km.

b. Available Data

The standard sequence of events includes the execution of a midcourse maneuver, if necessary, during the first Goldstone pass. Therefore, determination of the final premidcourse maneuver must begin seven (7) hours prior to the Goldstone end-of-view so that the following planned operations can be executed:

(1) The final premidcourse orbit determination,

(2) The calculation of the midcourse maneuver,

(3) The transmission and verification of commands, and

(4) Sun and Earth reacquisition and post maneuver tracking and telemetry.

2. Class II Requirements

There are two Class II requirements. They are listed below in the order of their priority:

(1) The semimajor axis of the 1-σ ellipse must be $\leq$ 150 km using all tracking data available up to Johannesburg set minus seven hours (approximately L + 4 hours).
A maneuver could then be executed during the Johannesburg pass, if desired, and still meet the required premidcourse orbit determination accuracy requirement.

(2) The semimajor axis of the 1-σ ellipse must be $\leq$ 30 km using all tracking data available seven (7) hours before set time on the first Goldstone pass.
The orbit determination uncertainties would then be comparable to the expected execution errors over the whole ensemble of corrections as determined by the

statistical description of the injection vehicle inaccuracies. This figure is to be contrasted with the figure given for the Class I requirement which assumed that a full 60 M/S maneuver was performed.

3. Class III Requirements

The semimajor axis of the 1-σ ellipse must be $\leq$ 3 km seven (7) hours before the end of the Goldstone pass.

The orbit determination uncertainties would be negligible (1/10) in comparison with the midcourse execution errors.

C. Tracking and Data Accuracy Coverage Required of AMR

The AMR is required to determine the orbit of the launch vehicle to satisfy a variety of needs. Each of these requirements is described below, first for the launch vehicle and second for the spacecraft.

1. Launch Vehicle Orbit Determination

The AMR must provide tracking coverage of the launch vehicle for orbit determination to satisfy five (5) specific needs. These are Range Safety, launch vehicle performance evaluation, AMR look angle calculation, spacecraft orbit determination and launch vehicle post retro-maneuver orbit determination. Tracking coverage requirements to satisfy these five (5) needs are developed in Subparagraphs a through e following.

a. Range Safety

Launches from AMR are monitored during the early phase of the flight by AMR Range Safety. Range Safety has the responsibility to destroy the vehicle via an RF destruct command link in the event the vehicle violates any destruct criterion. The AMR maintains a destruct capability throughout the ascent into the parking orbit. Destruct capability is disabled a few seconds after entry into the parking orbit. Tracking (and telemetry) data are needed by range safety during this phase.

AMR has, heretofore, been able to provide the tracking coverage required to permit launches of Rangers and Mariners in a sector between 93-111 degrees east of north. It is expected that this capability can support a launch between 90-114 degrees. However, range safety policy may not allow a sector greater than 93-111 degrees (see Appendix D).

A launch hold can be called if certain range tracking stations which provide mandatory coverage for range safety are inoperative. Such information will be given to the Project Manager by the NASA Test Support Office (NTSO), both prior to the launch and during the countdown. The Project Manager also has a direct phone to the Superintendent of Range Operations (SRO) during the countdown.

In summary, adequate tracking coverage for range safety purposes does exist if all AMR stations required are operating. "Down" stations, however, may result in a hold.

b. Launch Vehicle Performance Evaluation

Tracking data are required by the NASA launch vehicle agency (Lewis Research Center, LeRC) for launch vehicle evaluation. These data are required (Class I) for a short time after each of the Agena burns, and data are desired during the powered flight phases. Table B-II shows these requirements.

c. AMR Look Angle Calculation

The AMR provides inflight data to the downrange tracking stations as an acquisition aid. Generation of these look angles depends on adequate uprange tracking. These look angle calculations are based on data gathered in support of requirements placed in the other four areas now being discussed. Hence, these requirements usually will not, of themselves, constrain a launch. Information on constraints is received via the channels described in a, above. These requirements are presented in Table B-II.

d. Spacecraft Orbit Determination

The AMR tracks the C-band beacon in the Agena stage. Until separation the orbits of spacecraft and Agena are the same. At separation a relative velocity of about 2 ft/sec is imparted by a spring system which does not alter the total momentum. Since the separation velocity is small the AMR tracking of the Agena stage, both prior to and subsequent to separation, is very valuable in determining the spacecraft orbit and in checking other tracking systems. A further complicating factor is the

Table B-II. Launch vehicle tracking coverage required of AMR (Requirements placed by LeRC)*

Metric launch data							
Item no.	Data required	Interval	Data points/sec	Class I	Class II	Class III	Purpose and remarks
1	Position X, Y, Z	0-2000 ft	10	±2 ft	±1/2 ft		1. Required for over-all evaluation of stage performance or gross malfunction analysis. Also for analysis of vehicle roll and pitch program performance.
2	Velocity V_X, V_Y, V_Z, V_R	0-2000 ft	10	±2 ft/sec	±1/2 ft		
3	Acceleration A_X, A_Y, A_Z, A_R	0-2000 ft	10	±1 ft/ sec^2	±1/2 ft/sec^2		
4	Position X, Y, Z	2000-5000 ft	10	±10 ft	±1 ft		2. Optical position data reference to bottom horizontal Stage II paint pattern line.
5	Velocity V_X, V_Y, V_Z, V_R	2000-5000 ft	10	±5 ft/sec	±1/2 ft/sec		3. Continuous tracking required.
6	Acceleration A_X, A_Y, A_Z, A_R	2000-5000 ft	10	± 2 ft/sec^2	±1/2 ft/sec^2		
7	Position X, Y, Z	5000-100,000 ft	10	±10 ft	±2 ft		
8	Velocity V_X, V_Y, V_Z, V_R	5000-100,000 ft	10	±10 ft/sec	±5 ft/sec		
9	Acceleration A_X, A_Y, A_Z, A_R	5000-100,000 ft	10	±10 ft/sec^2	±5 ft/sec^2		
10	Position X, Y, Z	100,000 ft thru VECO + 1 sec to Stage I/II Separation	10	±500 ft	±250 ft		4. Evaluation of Stage I and II guidance and control system performance. Continuous tracking required.
11	Velocity V_X, V_Y, V_Z, V_R	Same as previous one	10	±10 ft/sec	±5 ft/sec		5. Items 1 through 3 are joint GD/A, LMSC requirements; item 4 is a LMSC requirement. (Remark No. 4 applicable to items 11, 12, 13, 14)
12	Acceleration A_X, A_Y, A_Z, A_R	Same as previous one	10	±10 ft/sec^2	±5 ft/sec^2		
13	Radar Polar Coordinate data (corrected azimuth, elevation and slant range)	Launch to Stage I/II Separation	10	±500 ft	±250 ft		
14	Position and velocity data (GE requirement)	T + 20 sec until burnout plus 50 sec	10		Best available		

*Data in Table B-II are obtained from Booster Requirements Document (BRD) NOU901 SLV - 3/5 - 01/S - 01 A, dated 17 November 1962.

Table B-II. (Cont'd)

Item no.	Data required	Interval	Data points/sec	Class I	Class II	Class III	Purpose and remarks
Metric midcourse data							
1	Position X, Y, Z	Stage I/II separation thru 1st burn cutoff ±60 sec	10	±10,000 ft	±1000 ft	±200 ft	To determine parking orbit injection conditions and to enable trajectory analysis.
2	Velocity V_X, V_Y, V_Z, V_R		10	±200 ft/sec	±20 ft/sec	±2 ft/sec	(LMSC Requirements)
3	Radar polar coordinate data, corrected azimuth, elevation, slant range	Same as above	10	±10,000 ft	±1000 ft	±200 ft	
4	H	Same as above	10	±10,000 ft	±1000 ft	±200 ft	
Metric orbital and space data							
1	Position X, Y, Z	Stage II 2nd burn ignition minus 10 sec to 2nd burn cutoff	10		±10,000 ft	±1000 ft	Stage II restart and powered flight. To determine injection conditions and vehicle performance.
2	Velocity V_X, V_Y, V_Z, V_R	Same as above	10		±200 ft/sec	±20 ft/sec	(LMSC Requirements)
3	Radar Polar coordinate data, corrected azimuth, elevation, and slant range	Same as above	10		±10,000 ft	±1000 ft	
4	H	Same as above	10	±10,000 ft	±1000 ft	±200 ft	
5	Position X, Y, Z	Stage II 2nd burn cutoff to retro maneuver.	10	±10,000 ft	±1000 ft	±200 ft	Final stage vehicle mission trajectory. To determine injection conditions and vehicle performance.
6	Velocity V_X, V_Y, V_Z, V_R	It is mandatory that any 60 sec of continuous tracking data be obtained during this interval.	10	±200 ft/sec	±20 ft/sec	±2 ft/sec	Track of the 2nd stage for as long as possible after retro maneuver (not to exceed 3 hr after injection) is desirable to support secondary test objectives. This requirement for post retro-maneuver shall not be allowed to constrain the possible firing window which might otherwise be available.
7	Radar Polar coordinate data, corrected azimuth, elevation and slant range.	Same as above	10	±10,000 ft	±1000 ft	±200 ft	*Events are used to determine intervals as they vary with the mission. (LMSC Requirements)
8	H	Same as above	10	±10,000 ft	±1000 ft	±200 ft	

retro-maneuver applied to the Agena stage several minutes after separation. However, even tracking information after this event is helpful during the flight.

It is clear that the processing of AMR raw data after injection into the transfer orbit is involved and conditional on telemetry identification of certain events. The relative weighting of the different AMR data types, e.g., range and angles, with respect to DSIF data is a task requiring more information than is available to AMR. Hence, it is important that raw data be supplied. Therefore, requirements are placed by JPL stating that the Agena orbit will be determined by AMR and that raw tracking data will be furnished JPL during launch. Raw data are herein defined as raw azimuth, elevation and range points which have not been altered by smoothing, weighting, etc. Two exceptions to this definition exist:

(1) It is desired that raw ships' data be corrected for ships' motion. However, ships' range data are valuable even if ships' motion has not been removed.

(2) It is permissible to remove blunder points from the data, prior to transmission to JPL/AMR during the launch.

These requirements result from the need to: 1) calculate DSIF look angles as an acquisition aid (see III-B); and 2) contribute to the calculation of the midcourse maneuver (see IV-B). These requirements are discussed in detail in Subparagraphs 1 and 2 following.

1) Calculation of DSIF Look Angles

Paragraph III-B-2 discussed in detail the prediction message accuracy for satisfactory look angles. These accuracy requirements are met if Class I data accuracy is met during the Class I intervals specified. In general, these intervals of coverage requirements fall immediately after injection into the parking orbit and immediately after injection into the transfer orbit. Table B-III describes these requirements. Paragraph III-B-2 states that DSIF Look Angles should be received at the site 10 minutes prior to the station

Table B-III. Launch vehicle tracking coverage required of AMR
(Requirements placed by JPL)

Table B-III. Launch vehicle tracking coverage required of AMR
(Requirements placed by JPL)

Event and coverage classification	Data required	Amount of data required (data pts/min)			Accuracy of data required		
		Class I	Class II	Class III	Class I	Class II	Class III
1st Agena Burnout to 1st Agena Burnout + 60 sec (Class I)	Range	2	10	10	1000m	10m	1m
	Azimuth Elevation				0.5	0.02	0.005
1st Agena cutoff to 1st Agena cutoff + 180 sec (Class II)	Range	2	10	10	1000m	10m	1m
	Azimuth Elevation				0.5	0.02	0.005
1st Agena cutoff to 2nd Agena ignition (Class III)	Range	2	10	10	1000m	10m	1m
	Azimuth Elevation				0.5	0.02	0.005
Any continuous 60 sec between injection and Agena retro (Class I)	Range	2	10	10	1000m	10m	1m
	Azimuth Elevation				0.5	0.02	0.005
Injection to injection + 2 hrs (Class II)	Range	2	10	10	1000m	10m	1m
	Azimuth Elevation				0.5	0.02	0.005
Injection to loss of track (Class III)	Range	2	10	10	1000m	10m	1m
	Azimuth Elevation				0.5	0.02	0.005

Requirements for raw data delivery to JPL/AMR

Class I	Class II
No later than L + one (1) hour	Near real time (within 2 min of the event)

view. Hence, the AMR operations must be designed to provide these look angles within a few minutes after receiving the raw tracking data.

2) Calculation of the Midcourse Maneuver

Raw tracking data are required from AMR by JPL/ Pasadena for two purposes.

a) Spacecraft Orbit Determination Reliability

The reliability of the spacecraft orbit determination is closely correlated with the number of tracking stations contributing data. An independent third data source can, for example, prove invaluable in resolving apparent discrepancies between two other data sources, both of which appear to be operating properly.

Also it is obvious that data source redundancy during the parking orbit and during the transfer orbit is valuable during each phase, respectively. However, two additional points are very important. First, raw data obtained during the parking orbit can be very useful in resolving apparent discrepancies between two stations tracking during the transfer orbit. Second, ships' data can be exceedingly valuable, under a variety of circumstances. For example, errors in ships' location can, under certain circumstances, have a negligible effect on the value of the tracking data. Also, ships' range data are always valuable, even if the data are uncorrected for ships' motion. These examples are typical and not at all unlikely occurrences. Many similar situations can be described.

In summary then, parking orbit raw data are valuable to JPL for both parking orbit and transfer orbit application, and ships' data can be valuable even with large errors in heading and location. Of course, AMR land station raw data, then, are even more useful.

b) Spacecraft Orbit Determination Accuracy

AMR raw data are also used in improving the accuracy of the spacecraft premidcourse orbit determination process. However, the data must be more accurate for this application than for the improved reliability discussed in 2.a. above. In general, data with Class II accuracy can be used occasionally in calculating the spacecraft orbit prior to the midcourse maneuver calculation. Use of Class II data would be particularly likely when early DSIF data were missing due to, perhaps, a short overhead pass with excessive tracking rates, or when a block of early DSIF data was missing due to equipment failure. Class III data would have sufficient accuracy to be used regularly in calculating the spacecraft premidcourse orbit. These data requirements are described in Table B-III.

c) Raw Data Delivery Requirements

The reliability and accuracy of the spacecraft orbit can be improved with AMR raw tracking data if the data arrives at the Flight Operations Facility in time. The orbit determination process begins at injection which always occurs within 40 minutes of launch. Therefore, Class I data delivery requirements are as follows:

Class I	AMR raw tracking data must be delivered to JPL/AMR no later than L + 1 hour.

It is desirable to have the data delivered in near-real time (within two (2) minutes of reception) to increase the time in which the data can be processed prior to the beginning of the orbit determination process and to insure the capability of meeting the Class II orbit determination requirements. Also, the data would then be available for JPL calculation of DSIF look angles in the event some system failure prevented AMR from fulfilling this function. Therefore, Class II data delivery requirements are as follows:

Class II	AMR raw tracking data must be received at JPL/AMR in near real-time (within two minutes of the event).

e. Launch Vehicle Post Retro Maneuver Orbit Determination

It is desirable to be able to calculate the orbit of the launch vehicle after it has executed its retro maneuver. However, such information is not essential to the success of the mission, and it is, therefore, a Class II requirement. This requirement is specified in Table B-III.

2. Spacecraft Orbit Determination

There is no requirement for AMR tracking of the spacecraft.

D. Tracking Data Accuracy and Coverage Required of DSIF

Requirements placed on the DSIF are to track the spacecraft; there are no requirements on the DSIF to track the launch vehicle.

Premidcourse orbits of the spacecraft are required for two reasons. These reasons and the corresponding data accuracy and coverage requirements are discussed in Subparagraphs 1 and 2 below.

1. Requirements for Premidcourse Maneuver Orbits

There are two requirements for premidcourse maneuver orbits. These requirements are describedas follows:

(1) DSIF Look Angle Calculation

An early orbit of the spacecraft must be determined to allow calculation of look angles for subsequent tracking. In general, the DSIF initial acquisitions are made with the aid of preflight nominal graphs and inflight prediction messages based on the liftoff nominal trajectory and also the actual orbit an determined by AMR. Subsequent acquisitions are made with messages based on orbits calculated from data obtained to satisfy the requirements in Subparagraph b. below. Therefore, no additional requirements for coverage are placed.

(2) Midcourse Maneuver Calculation

A final premidcourse maneuver orbit of the spacecraft must be determined to permit subsequent calculations of the appropriate maneuver.

2. Requirements for Data Accuracy and Tracking Coverage

The orbit determination accuracy requirements of the Ranger Block III mission are stated in Paragraph IV-B. In order to meet these requirements, raw tracking data from the DSIF stations must be provided. These data will be contaminated with noise to some degree, and the amount of data that will be received will vary. Therefore, it is required that the expected accuracy of the data (Data Accuracy) be specified as well as the amount of data needed (Tracking Coverage).

a. Data Accuracy

Raw tracking data in the form of two-way doppler, three-way doppler, and antenna pointing angles are provided by the DSIF for orbit determination. These data will contain noise due to correlations in the data, variation in refraction correction, oscillator drift, cycle count drops, transmitter variations, etc. Therefore, it is necessary to specify the amount of noise which can be expected, so that the a priori orbit determination capability can be predicted as the launch azimuth and launch day are varied.

Estimates of the data accuracy to be expected during the Ranger Block III missions have been made. These estimates are listed in Table B-I, Part II as Ranger Block III Data Accuracy Requirements. These requirements are now being used by Section 312 in the orbit determination capability study for the Block III mission.

The orbit determination capability can be significantly improved as the quality of the tracking data improves. Therefore, Table B-I, Part II contains a listing of data accuracy which is "highly desirable" and also a listing of data accuracy which represents the "ultimate" in data accuracy desired. This discussion of data accuracy will be concluded now with two (2) additional comments.

(1) It should be remembered that this document is concerned solely with the launch to L + 3 hours phase of the Ranger Block III missions. Therefore, data accuracy requirements for other missions or for the coast and encounter phase of Ranger missions are not discussed.

(2) It is beyond the scope of this document to discuss in sufficient detail the ground rules used in determining the data accuracy to be expected during the Ranger Block III missions. Suffice it to say that these specifications represent the current best estimate of the "guaranteed" data quality for the Ranger Block III

missions based on past experience. Continued up dating of these estimates will be made, of course, as more experience is accumulated.

b. Tracking Coverage

With the quality of the tracking data defined (Subparagraph 2 preceding), it is now possible to specify the tracking coverage required to meet the orbit determination requirements specified in Paragraph IV-B. However, several ground rules must be stated and agreed upon first, in order that this complex problem can be simplified and reduced to its essential parts.

(1) The primary objective (used throughout this document as a guideline) is to enhance the probability of achieving a mission success.

It is required that the Class I orbit determination requirements be met to ensure achieving the primary mission objectives.

It may be required (second order effect) that Class II orbit determination accuracy requirements be met to ensure a mission success.

Finally, it is not required that Class III orbit determination accuracy requirements be met to ensure achieving a mission success.

Therefore, the greatest effort will be directed toward describing how best to meet Class I orbit determination accuracy requirements. Enough discussion will be presented on how to meet Class II orbit determination accuracy requirements so that a general understanding of the problem will be possible. No time will be spent on describing requirements necessary to meet Class III orbit determination accuracy.

(2) Class I tracking coverage requirements in support of the Class I orbit determination accuracy requirement will be specified on the assumption that each station which must supply good tracking data will, in fact, produce such data. Thus, the integrity of the Class I definition will remain intact. However, on several occasions a tracking site has appeared to be operating satisfactorily and yet the data were in error and this fact went undetected in real time. Such an occurence

is particularily likely during a difficult first pass. Therefore, one concludes that it is very desirable to assign additional DSIF stations to a tracking pattern arranged to provide redundancy, thereby minimizing the probability of not achieving the Class I orbit determination accuracy. This policy will be exploited in establishing Class II tracking coverage requirements in support of the Class I orbit determination accuracy requirement.

(3) Class I and Class II tracking coverage requirements in support of the Class II orbit determination accuracy requirements must also be specified. A policy similar to that used to describe the coverage in support of Class I orbit accuracy will be used.

(4) Answers to the following questions must be provided in this document for all days and all launch azimuths:

  (a) Which DSIF stations must be "up" (predicted to be operating at the time of their view) to permit the launch. (This represents the Class I tracking coverage in support of the Class I orbit determination accuracy requirements.)

  (b) Once liftoff occurs, which tracking pattern will maximize the probability of achieving the Class I orbit determination accuracy requirements, acknowledging known DSIF failures, if any, and potential failures, both detectable and undetectable in real time.

  (c) Can the Class II orbit determination accuracy requirements be met, and can the SFOP exploit this capability without degrading the probability of achieving the Class I orbit determination accuracy requirements. This question must be answered both during the pre launch planning and the post launch real-time operations.

(5) It is assumed that the Class I orbit determination accuracy requirements must be met to ensure mission success. This fact represents the point from which all departures are made. However, it must be emphasized that the mission can succeed (although it cannot be so "guaranteed" prior to launch) even though the Class I orbit determination accuracy requirement

is not met. For example, the midcourse maneuver can be delayed past the Goldstone first view so that additional tracking can be obtained to define the orbit to the 1-σ - 150 km specification. However, this procedure is undesirable for preflight standard procedures because: (1) Goldstone is considered the best station from which to conduct a maneuver, and (2) the midcourse maneuver capability to correct injection guidance dispersions diminishes as the maneuver time is delayed.

These five (5) ground rules have been followed in establishing the tracking coverage requirements listed in Table B-I Part IV.

It is beyond the scope of this first issue of the Launch Constraints Document to specify the tracking coverage requirements on a day-by-day and launch azimuth-by-launch azimuth basis. However, the next edition of this document will contain such a plan. This document does contain the preliminary results of an orbit determination accuracy study which is still in progress. This study will determine the theoretical orbit determination accuracy achieved as a function of (1) amount of data obtained (2) data accuracy, (3) acquisition time, (4) data dropout and (5) incorporating AMR raw data.

These preliminary results are presented in Table B-I Part III and show that the Class I orbit determination accuracy requirement can be met, assuming injection to acquisition times of less than 30 minutes, without Goldstone data.

Table B-I Part IV also shows the current best estimate of the Class I and Class II DSIF station combinations required to satisfy the Class I and Class II orbit determination accuracy requirements.

Table B-I Part IV is, of course, greatly simplified and represents, at best, a first look at Ranger Block III tracking coverage requirements.

The revision to this document will present in tabular form the results from the orbit determination accuracy study. One of the tables will present the coverage required to satisfy

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the Class I and Class II orbit determination accuracy requirements for each launch day and for various launch azimuths within each day. The second of the two tables will display the theoretical impact statistics for several tracking patterns for approximately every third day of the launch period and for several launch azimuths.

V. TELEMETRY COVERAGE REQUIREMENTS

A. Introduction

Requirements for coverage of the spacecraft telemetry through the spacecraft L-band or Agena links are placed on the AMR and the DSIF. Requirements also exist for coverage of the vehicle telemetry for vehicle evaluation. These latter requirements are placed only on AMR.

B. Telemetry Coverage Required of AMR

Requirements for coverage of both launch vehicle and spacecraft telemetry are placed on AMR. These requirements are treated in Subparagraphs 1 and 2, following.

1. Launch Vehicle Evaluation

Evaluation of the Atlas and Agena performance requires coverage of the Atlas and Agena telemetry systems during certain phases of the flight.

In addition Range Safety requires certain vehicle telemetry data during the boost phase.

These requirements are presented in Table B-IV.

2. Spacecraft Evaluation

The spacecraft telemetry can be received by a station equipped at L-Band (960 mc) and also a station designed to receive Agena telemetry. The spacecraft transmitter (960 mc) is continuously radiating from liftoff and the telemetry signal also modulates the 90 Kc subcarrier of the Agena telemetry system. The AMR should exploit both links to satisfy spacecraft telemetry coverage requirements.

The requirements for coverage are stated herein and presented in Table B-V and B-VI as follows.

a. Class I

JPL justifies Class I requirements as necessary to satisfy the primary mission objectives. Hence, it is important that data

Table B-IV. Launch vehicle telemetry coverage required of AMR
(Requirements placed by LeRC)

Class I	Class II	Class III
During pre-launch calibrations on internal power and external power. From T -2 minutes to Agena first cutoff plus 20 sec. 20 sec before to 20 sec after Agena 2 nd burn 10 sec before to 5 sec after Agena/spacecraft separation	Same as Class I plus coverage (1) from Agena/spacecraft separation plus 5 sec to Agena/spacecraft separation plus two minutes, and (2) from 20 sec before to 1 min after Agena retro rocket firing maneuver.	Continuous coverage pre-launch calibrations plus continuous coverage from T -2 min to Agena retro maneuver rocket fire plus 1 min.

Table B-V. Launch vehicle telemetry coverage required of AMR
(Requirements placed by JPL for spacecraft data)

Class I	Class II	Class III
From Agena shroud separation minus 10-sec to Agena first ignition plus 20 sec.	From T -2 min to Agena/ spacecraft separation	Same as Class II

Note: 1. See Table B-VI

2. The spacecraft data via the spacecraft link or the Agena link are also required (Class I) at Hangar AE during the pre-launch checkout.

Table B-VI. Spacecraft telemetry coverage (L-band link) required of AMR and DSIF
(Requirements placed by JPL)

Class I	Class II	Class III
AMR From 10 sec before to 2 min after Agena/spacecraft separation	AMR From Agena/spacecraft separation to continuous DSIF view plus 5 min. Notes: 1. Continuous DSIF view will begin on all launch days for most or all launch azimuths at Johannesburg first pass rise (0 degree elevation angle). 2. Continuous DSIF view will always begin no later than Woomera first pass rise (0 degree elevation angle). 3. Continuous DSIF view will always begin between injection and injection plus 15 min, depending on launch day and launch azimuth.	AMR From launch -2 min to Agena/spacecraft separation plus Class II requirement. (Note: This requirement becomes a Class II requirement to the extent that the Class II requirement on Table B-V is not met.)
DSIF All view periods of more than five (5) min. (Note: See Appendix B, Subparagraph V-C Page B-29)	DSIF See Class I requirement	DSIF See Class I requirement.

be obtained so that changes to the succeeding spacecraft can be made in the event of a malfunction. The shroud separation and the Agena/spacecraft separation events are critical, and monitoring these functions will enhance the probability of mission success.

b. Class II

It is highly desirable that the performance of the spacecraft be continuously monitored throughout the mission from launch to impact. Such coverage is essential to guarantee meeting all of the mission objectives. The DSIF requires 5 minutes to complete their acquisition process.

Therefore, continuous coverage from launch to the point at which continuous DSIF view begins, plus 5 minutes, is considered a Class II requirement. Tables V and VI contain the tabulation of these requirements.

c. Class III

The Class III requirements are the same as those of Class II.

C. DSIF

The DSIF is required to obtain spacecraft telemetry coverage from L + 58 minutes to Launch plus three (3) hours. (The period from L + 3 hours to encounter is beyond the scope of this document.) This requirement reflects the fact that the spacecraft rise time at Woomera will not occur later than L + 54 minutes. Thus, coverage from Johannesburg and/or Woomera will be continuous after L + 54 minutes.

Requirements may also be placed on the DSIF (Johannesburg) to cover portions of the flight between launch and L + 58 minutes. The DSIF capabilities during this early period will be utilized, where possible, in harmony with the AMR facilities.

It is expected, however, that the majority of support during this early phase will be provided by AMR. It is assumed here that the L-Band TM Stations used by AMR are part of the AMR capability.

It is beyond the scope of this first issue of the launch constraints document to specify the requirements for coverage from the DSIF for each launch day for the Ranger Block III mission.

However, the subsequent editions of this document will specify the requirements for coverage on a day by day basis. These requirements will vary significantly from day to day as the injection loci move up and down range. However, the requirements will be consistent with the DSIF requirements and capability limitations described in Paragraph III-B-3. of this Appendix.

D. Data Delivery

1. AMR

There are no requirements for delivery of S/C data in real-time or near real-time from AMR to JPL. The telemetry data obtained by AMR during the preinjection and early postinjection phase will be used by JPL in post flight analysis.

However, the results from one launch will influence subsequent launches. Hence, data must be delivered in time for necessary analysis prior to the next launch opportunity. These needs are expressed in the class requirements listed below.

Class I — All data must be delivered to JPL/AMR no later than 5 calendar days after the launch.

Class II — It is required that data be delivered within 36 hours of the launch.

Class III — The Class III requirements state that a real-time (RF or cable retransmission to the Cape) data return is required.)

2. DSIF

Telemetry data are required from the DSIF in real time (within 5 minutes).

a. It is desirable that the composite spacecraft telemetry signal be relayed from the DSIF launch station to JPL/Pasadena from L -3 hours to T +5 minutes (shroud separation).

b. Capability for continuous real time transmission of data to JPL is required for all DSIF view periods of more than five (5) minutes.

NOTE: This requirement can be mandatory for some stations depending on launch geometry. The first revision to this document will attempt to evaluate this requirement on a launch day-by launch day basis.

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APPENDIX C. Tracking and Telemetry Coverage Capability

I. INTRODUCTION

The purpose of this appendix is to describe the tracking and telemetry coverage capability of the DSIF and the AMR in response to the requirements placed on these two agencies.

Two problems have prevented as thorough an analysis as will be possible later in the program.

The first problem is that each of the Ranger launch periods has, at the present time, seven (7) or eight (8) launch days. Further progress in the trajectory design will possibly eliminate one or more days in each period. However, the number of days still remaining in the period and the time allotted for this first issue precludes a detailed analysis of each launch day.

The second problem is that the AMR response to support capabilities is not expected until about August of this year. Therefore, all estimates of AMR support are those of the JPL Launch Constraint representative. In addition, ship support is usually essential in providing the necessary support for lunar and planetary missions, and AMR does not commit ship support until shortly before launch.

However, this appendix will serve to clarify the broad picture and to emphasize areas in which more information is needed.

This appendix will describe the tracking and telemetry coverage capability by first reviewing the requirements in Paragraph II following.

Paragraph III discusses briefly the facilities of the AMR and DSIF.

Paragraph IV describes the format in which the results will be presented.

The results and appropriate discussion as explained in Part II and enumeration of the resultant constraints are presented in Paragraph III of Appendix D, Launch Constraints.

II. TRACKING AND T/M REQUIREMENTS, REVIEW

Summarizing briefly, the Class I tracking and telemetry requirements of both the launch vehicle and the spacecraft.

A. Launch Vehicle Requirements

(1) T/M coverage during the entire powered flight ascent to parking orbit .

(2) T/M coverage during second Agena burn.

(3) T/M coverage during Agena/Spacecraft separation.

(4) Tracking from launch to parking orbit injection

(5) Tracking coverage for one (1) minute after parking orbit injection and for one (1) minute after transfer orbit injection.

B. Spacecraft Requirements

(1) Telemetry coverage at shroud separation.

(2) Telemetry coverage at Agena/Spacecraft separation.

(3) Adequate tracking coverage to allow the orbit to be determined to an accuracy (RMS uncertainty in semi-major axis) of less than 150 km at Goldstone set minus seven (7) hours.

III. AMR AND DSIF STATION CAPABILITIES

A. AMR Stations Capabilities

The coverage for the launch vehicle is provided by fixed land stations and mobile tracking and T/M ships provided by AMR. The land stations utilized in this report are:

Cape Canaveral
Grand Bahama Island
San Salvador
Puerto Rico (or Grand Turk)
Antigua
Ascension Island
Pretoria

All of these stations are capable of providing both T/M and tracking coverage with a horizon limitation in the parking orbit. (AMR guarantees coverage to 2° above the horizon.)

It was also assumed that two small T/M ships and one large tracking and telemetry ship of the Twin Falls Victory variety would be available. Guaranteed coverage from the small T/M ships is limited to a slant range of 270 n. miles which limits them almost exclusively to coverage during parking orbit or second burn since the altitude and hence slant range increases rapidly after injection. It was assumed that the tracking and telemetry ship has a maximum slant range limit of 850 n. miles and hence a much larger area of coverage than the small T/M ships.

While it is more or less certain that the land stations mentioned above will be available for the Ranger mission the situation is not that clear regarding ship support. The number and range of ships that will be committed to the Ranger mission will not be known until shortly before launch, probably a few weeks at best. However, it is felt that coverage assumed for this analysis has a reasonable chance of being implemented. At least one additional large tracking and T/M ship would be very desirable while any support less than that assumed for this study could possibly cause severe launch restrictions on some days of the launch period.

The AMR has three (3) L-Band telemetry stations which are used to provide coverage of the spacecraft at the spacecraft frequency. These stations are usually located either at AMR land stations or on AMR tracking or telemetry ships.

B. DSIF Stations Capabilities

The tracking and telemetry coverage for the spacecraft following separation will be provided by the DSIF stations at Johannesburg, Woomera, and Goldstone.

The three land stations of the DSIF provide both tracking and T/M coverage for the spacecraft throughout the mission.

IV. FORMAT OF RESULTS

The coverage capability is graphically presented in two formats, bargraphs and Earth tracks. The series of these illustrations comprise Figures C-1 through C-15.

The bargraphs (Figure C.2b) depict for a given launch day the coverage available as a function of time from launch and the launch plan (azimuth). (Due to time limitations only one bargraph has been included in this first document; however, in the final launch plan a similar bargraph will be included for each launch date of the launch period.) In Figure C-2b the bargraph is drawn for five discrete azimuths while in the final launch plan there will be information for each azimuth angle continuously.

The bargraphs are interpreted by selecting a launch azimuth and then by reading horizontally across the page, the coverage as a function of time from launch can be noted.

Also plotted on the graph are the loci of second burn times, injection, separation, and retro as functions of the times from launch and the azimuth angle. The horizontal lines denoted by the names of the tracking station represent the total time that the station can "see" the spacecraft. The bars across the top of each launch plan represent the composite coverage or the times at which at least one station is viewing the vehicle.

The Earth tracks (Figures C-2 to C-15) represent typical uprange and downrange injection loci for typical launch months.

Subsequent issues of this document will contain an analysis of each launch day, and this analysis will include, wherever possible, the AMR estimates of range support.

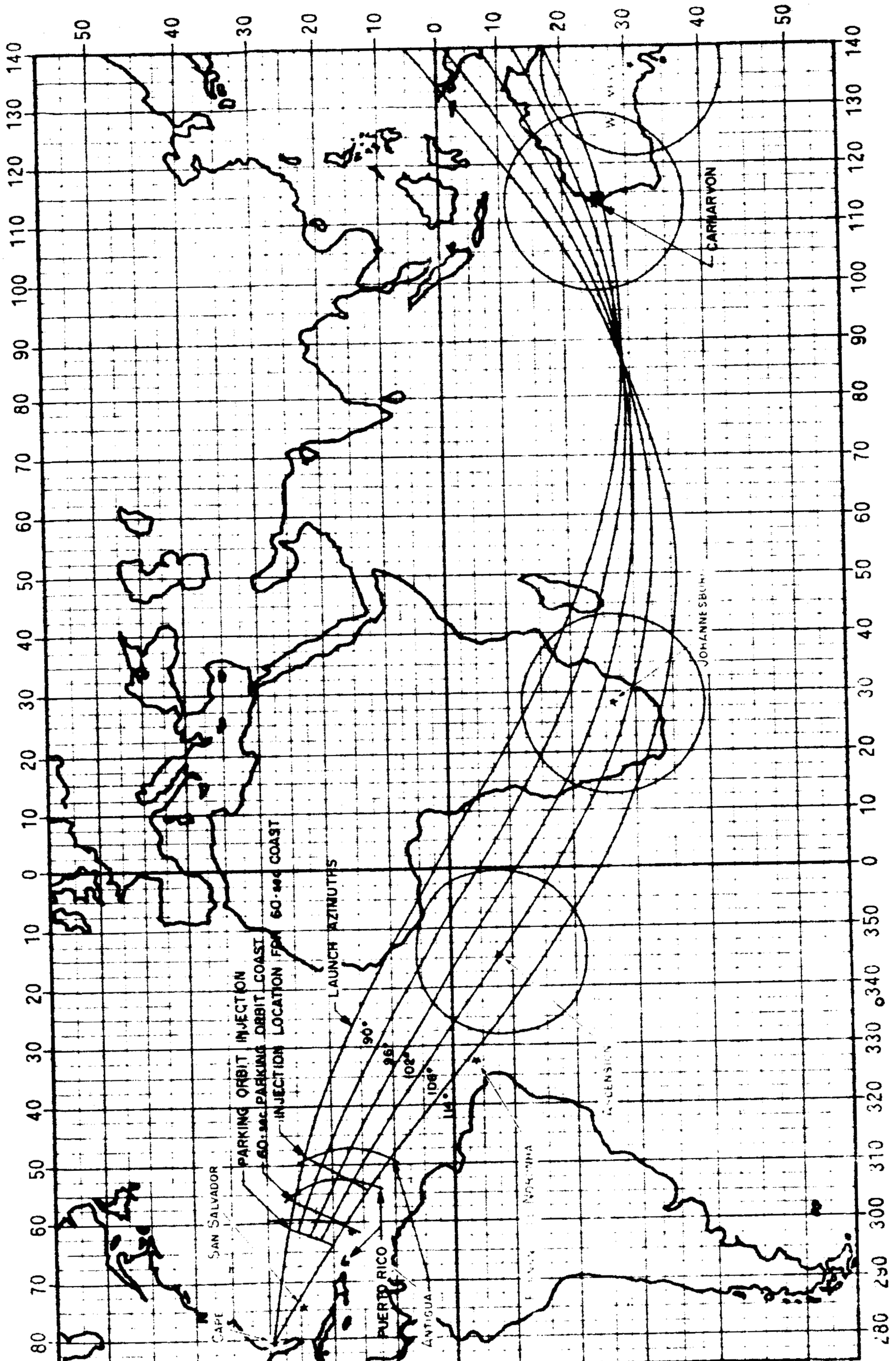

Fig. C-1. Ranger Parking Orbit Earth Track

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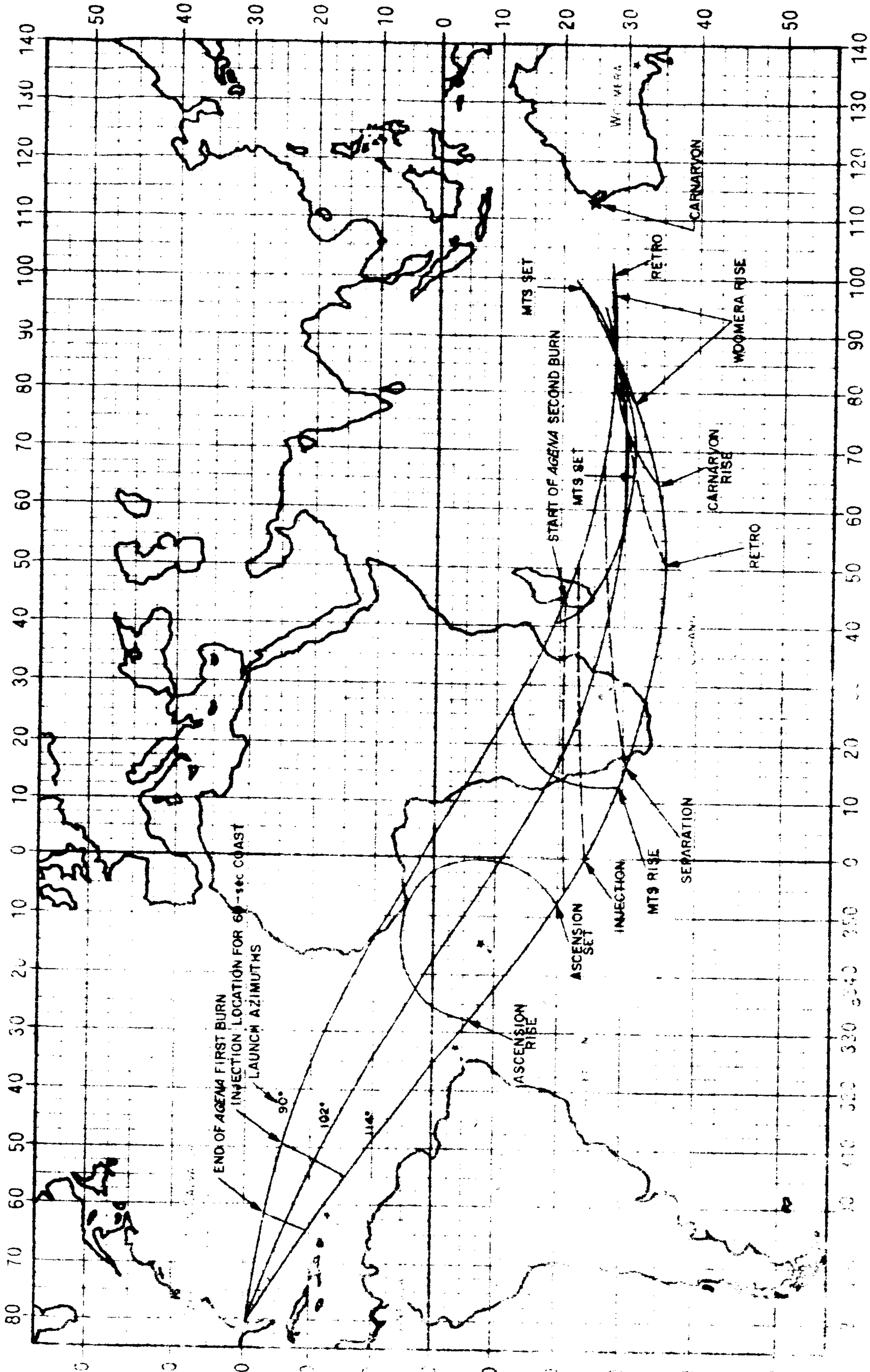

Fig. C-2a. Ranger Injection Loci for Dec. 2, 1963

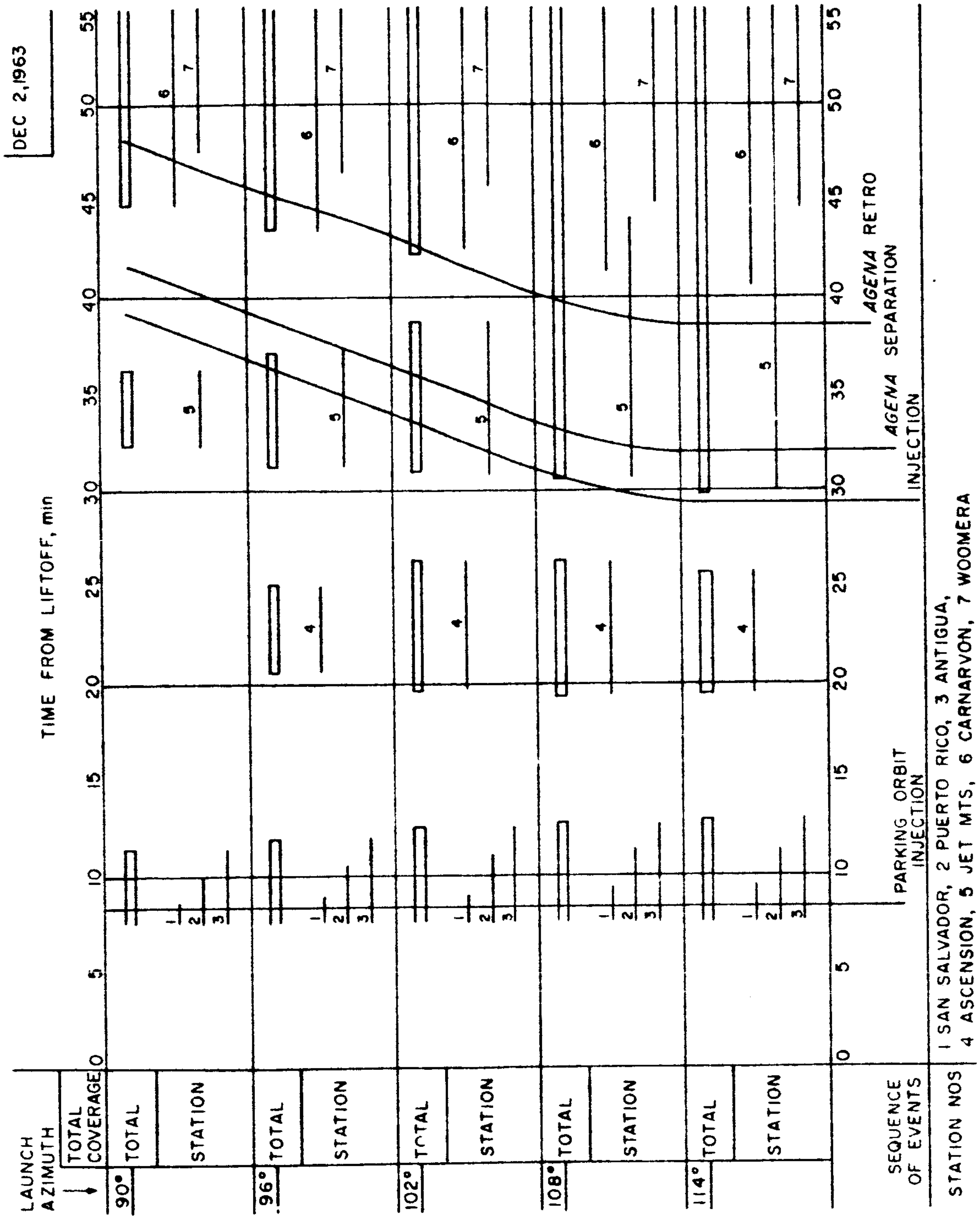

Fig. C-2b. Bargraph

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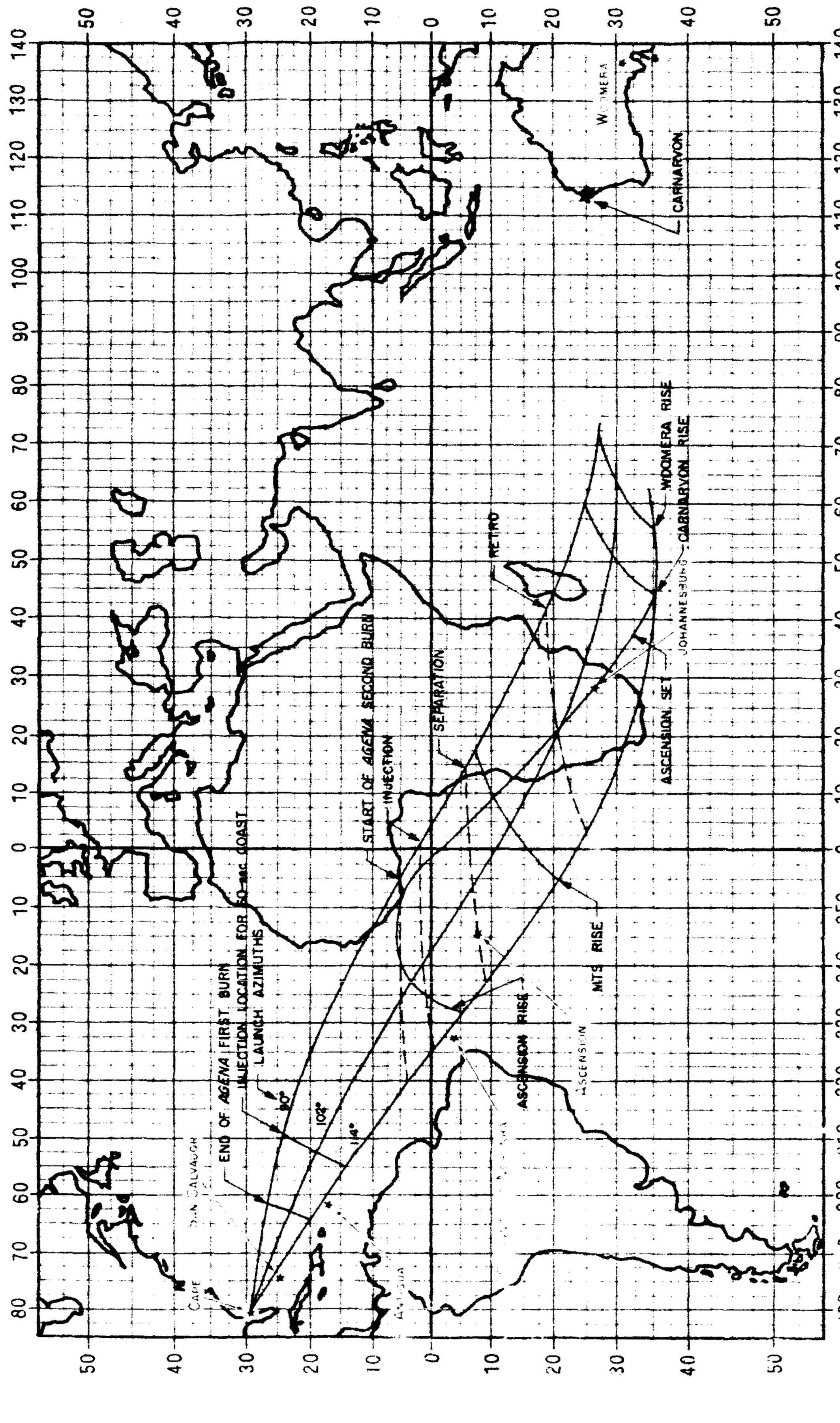

Fig. C-3. Ranger Injection Loci for Dec. 8, 1963

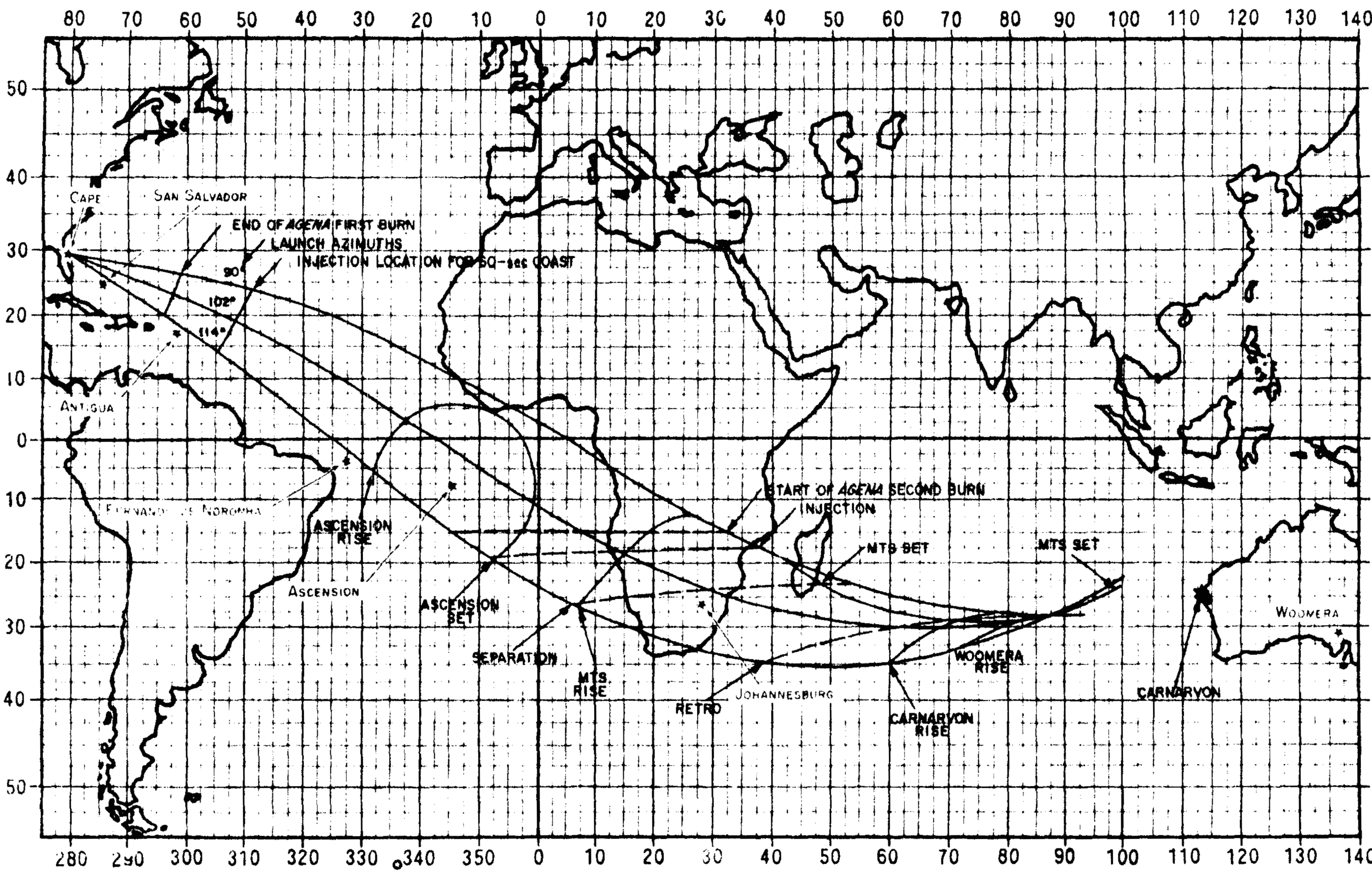

Fig. C-4. Ranger Injection Loci for Dec. 31, 1963

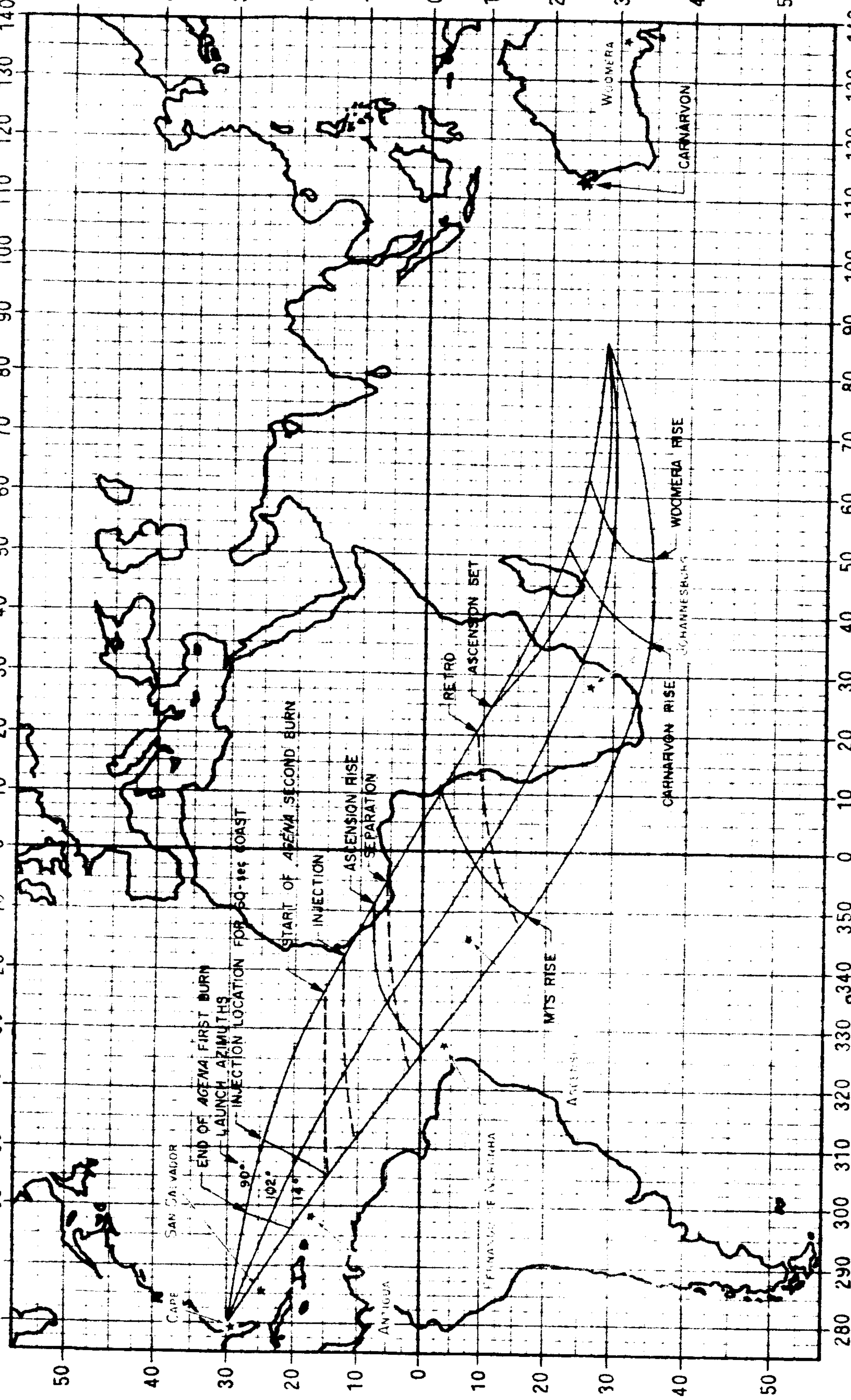

Fig. C-5. Ranger Injection Loci for Jan. 8, 1964

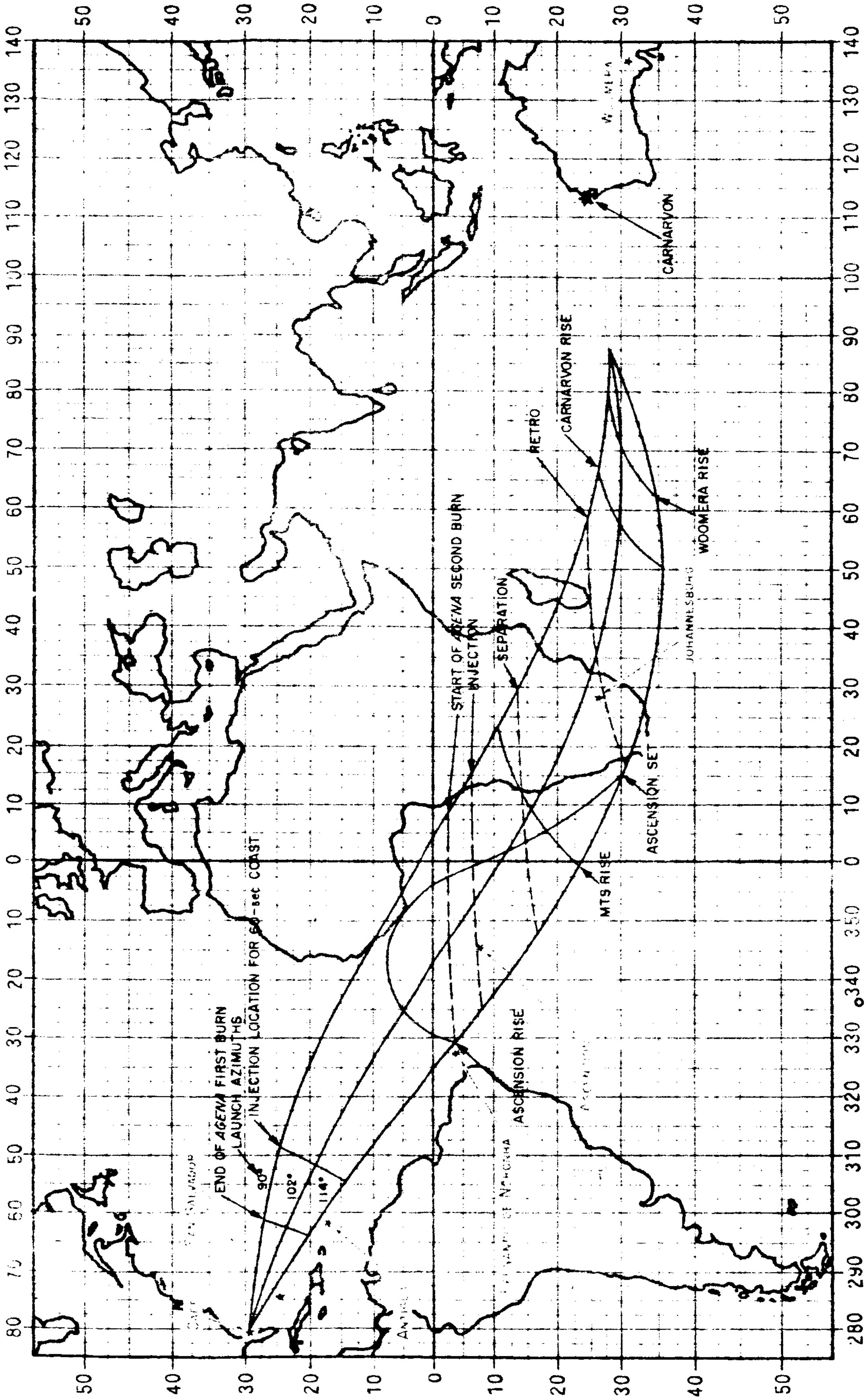

Fig. C-6. Ranger Injection Loci for Jan. 30, 1964

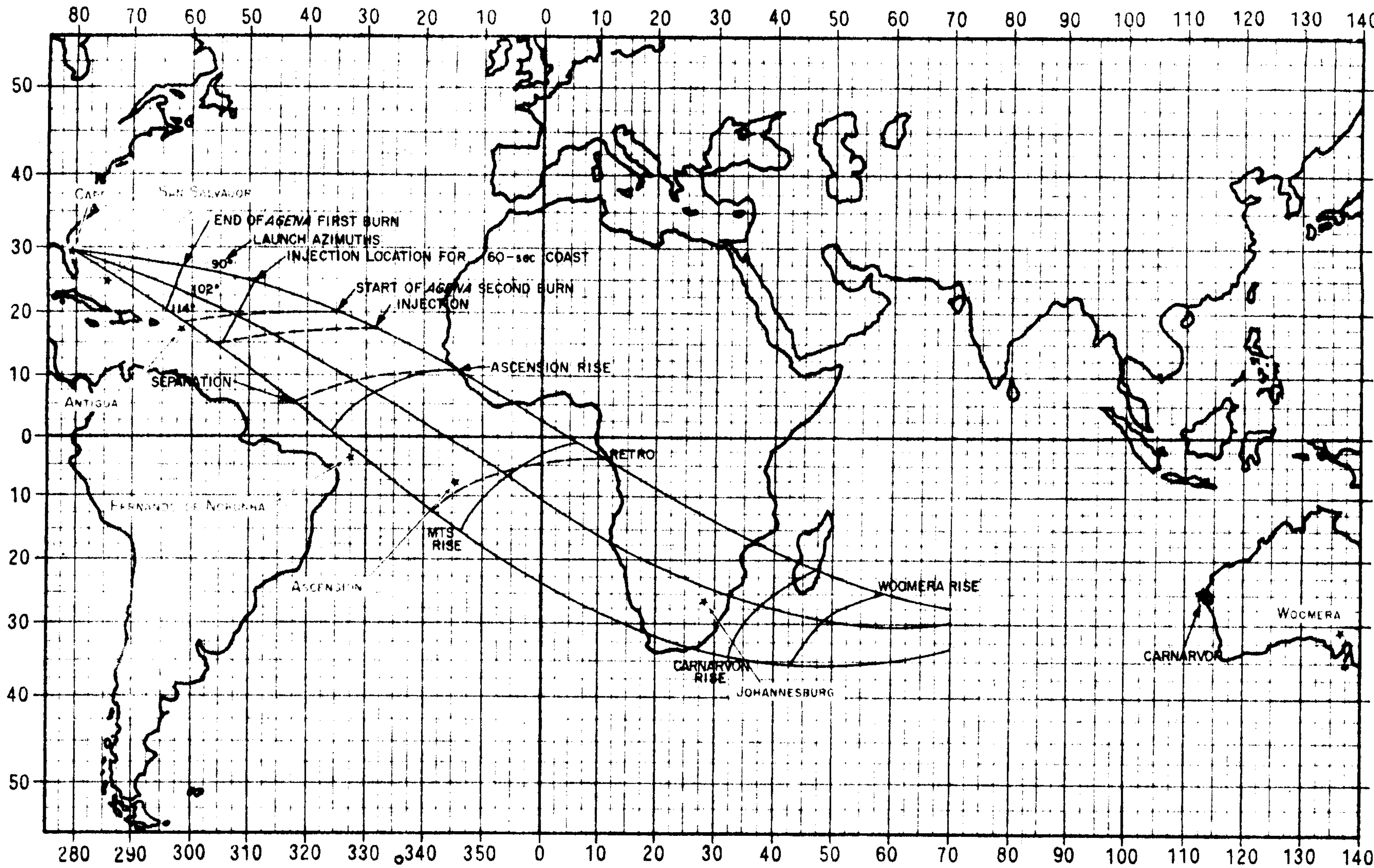

Fig. C-7. Ranger Injection Loci for Feb. 6, 1964

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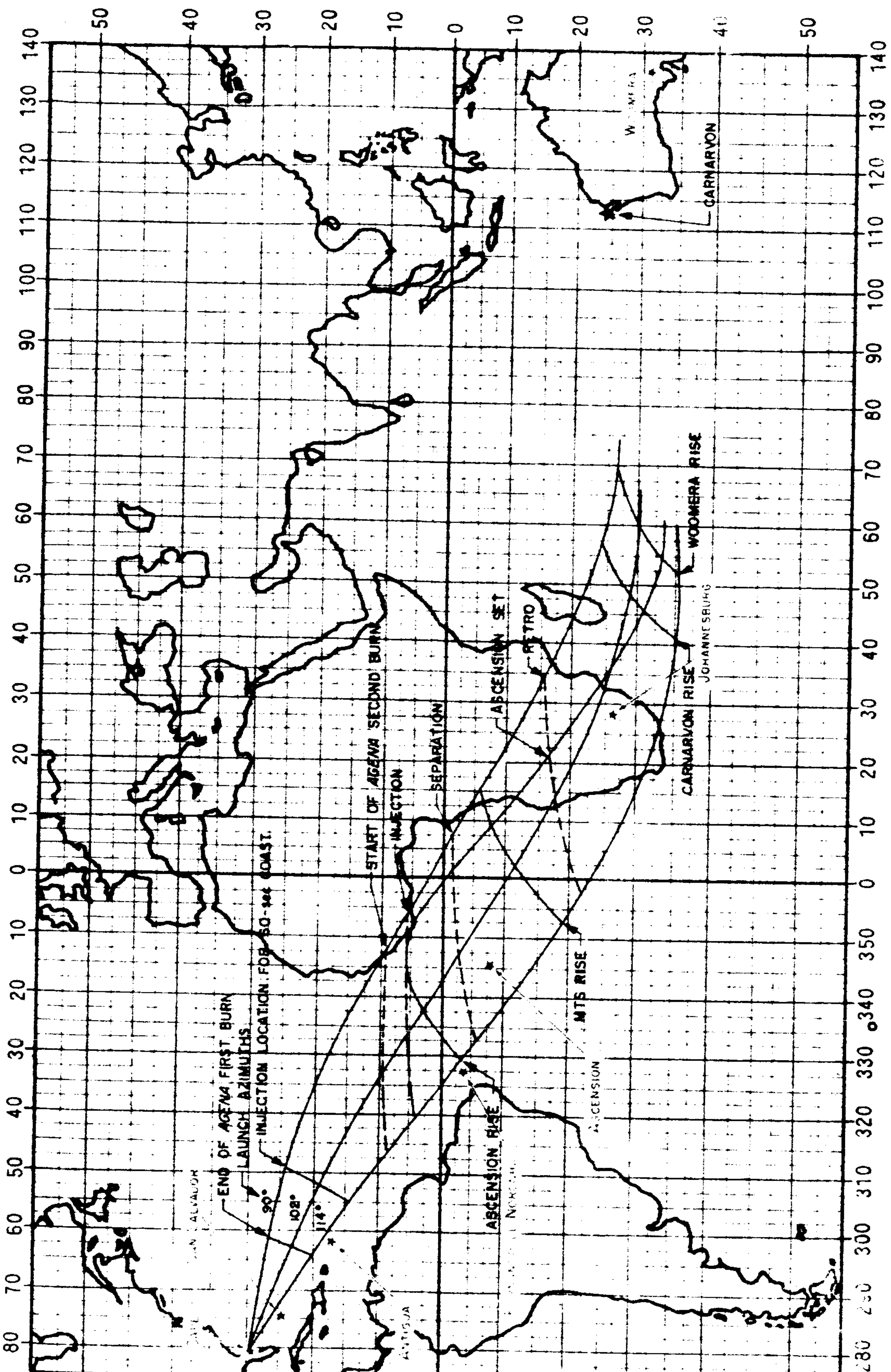

Fig. C-8. Ranger Injection Loci for Feb. 29, 1964

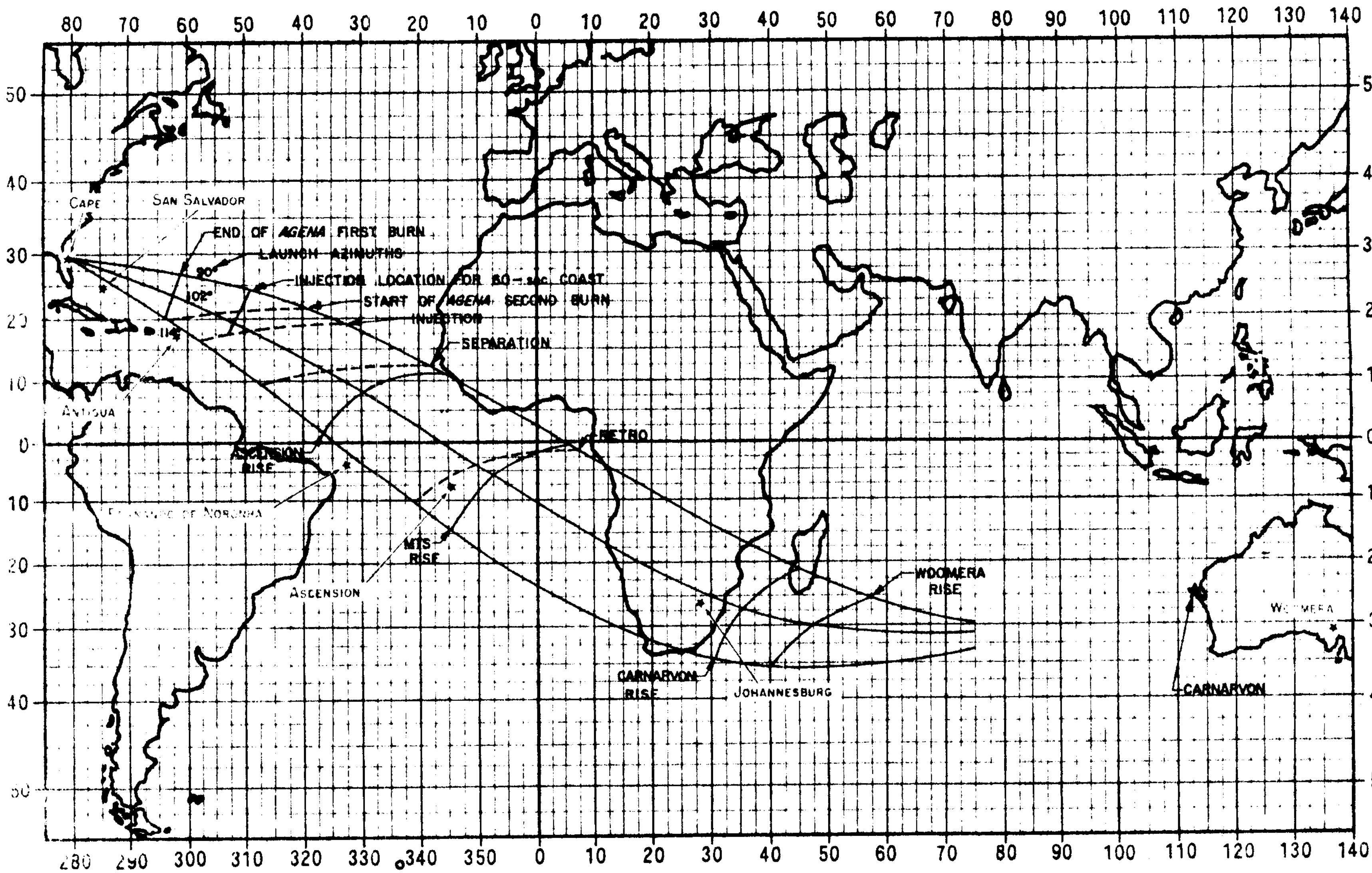

Fig. C-9. Ranger Injection Loci for Mar. 6, 1964

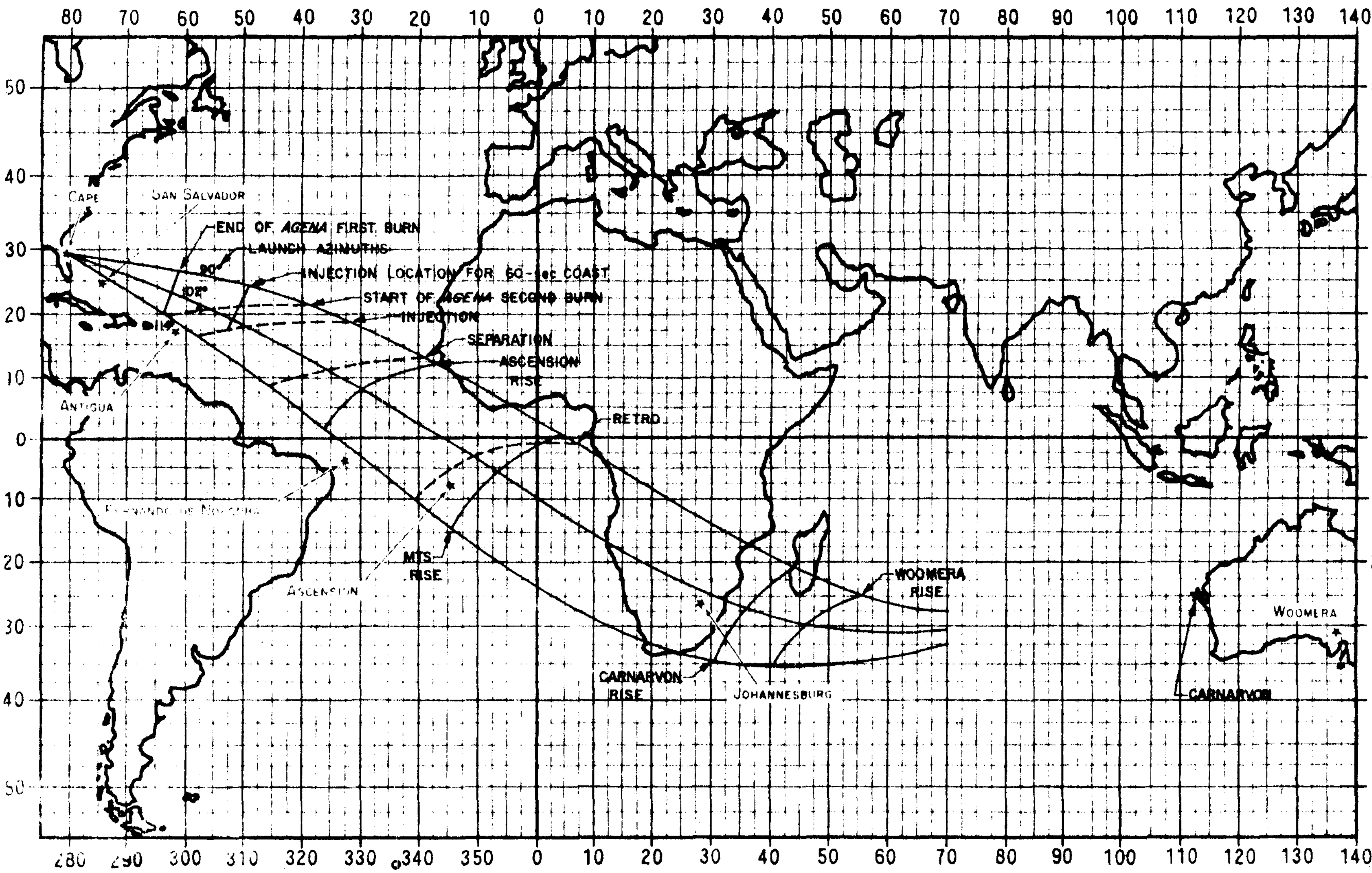

Fig. C-10. Ranger Injection Loci for Apr. 1, 1964

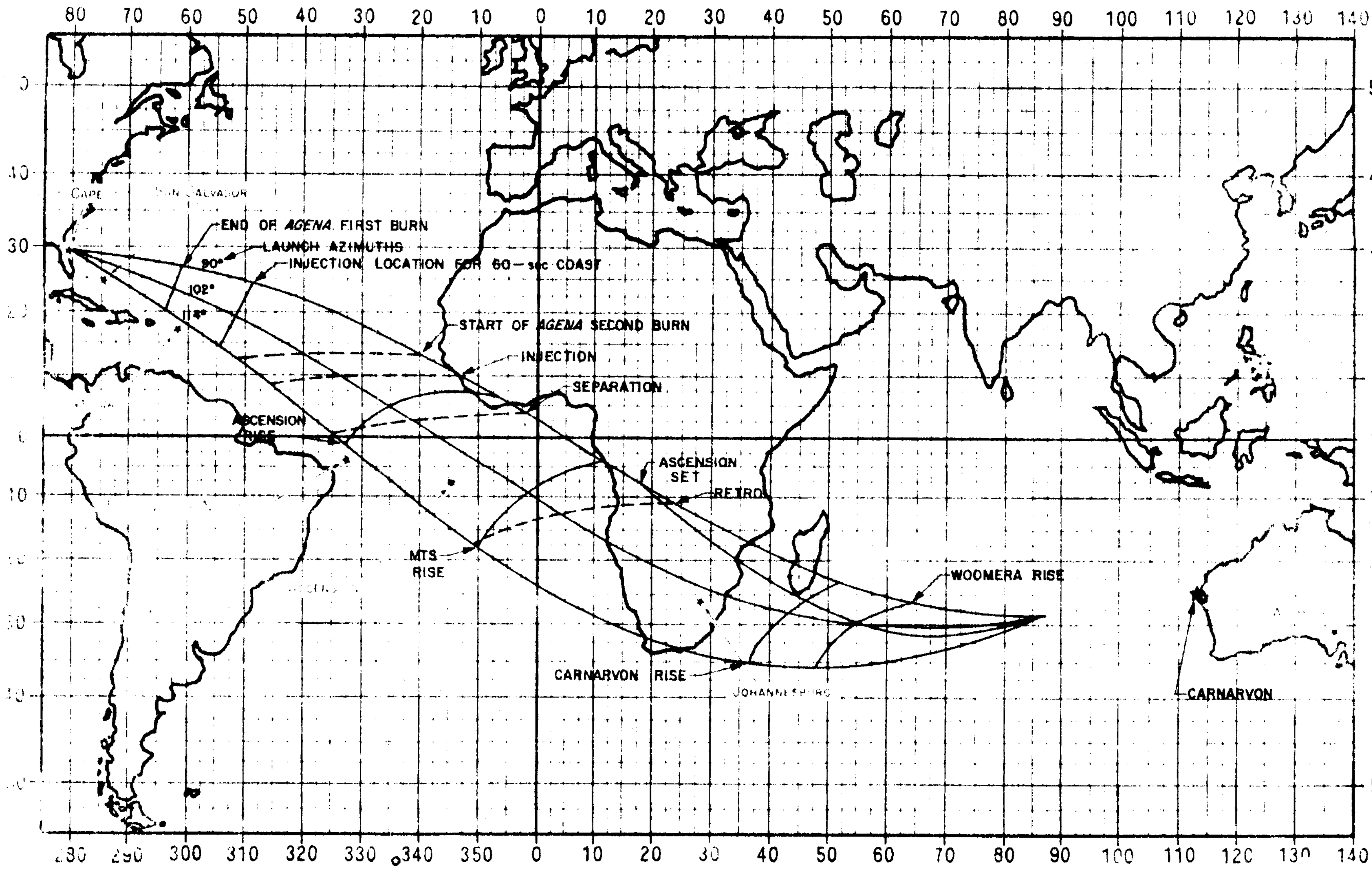

Fig. C-11. Ranger Injection Loci for Apr. 5, 1964

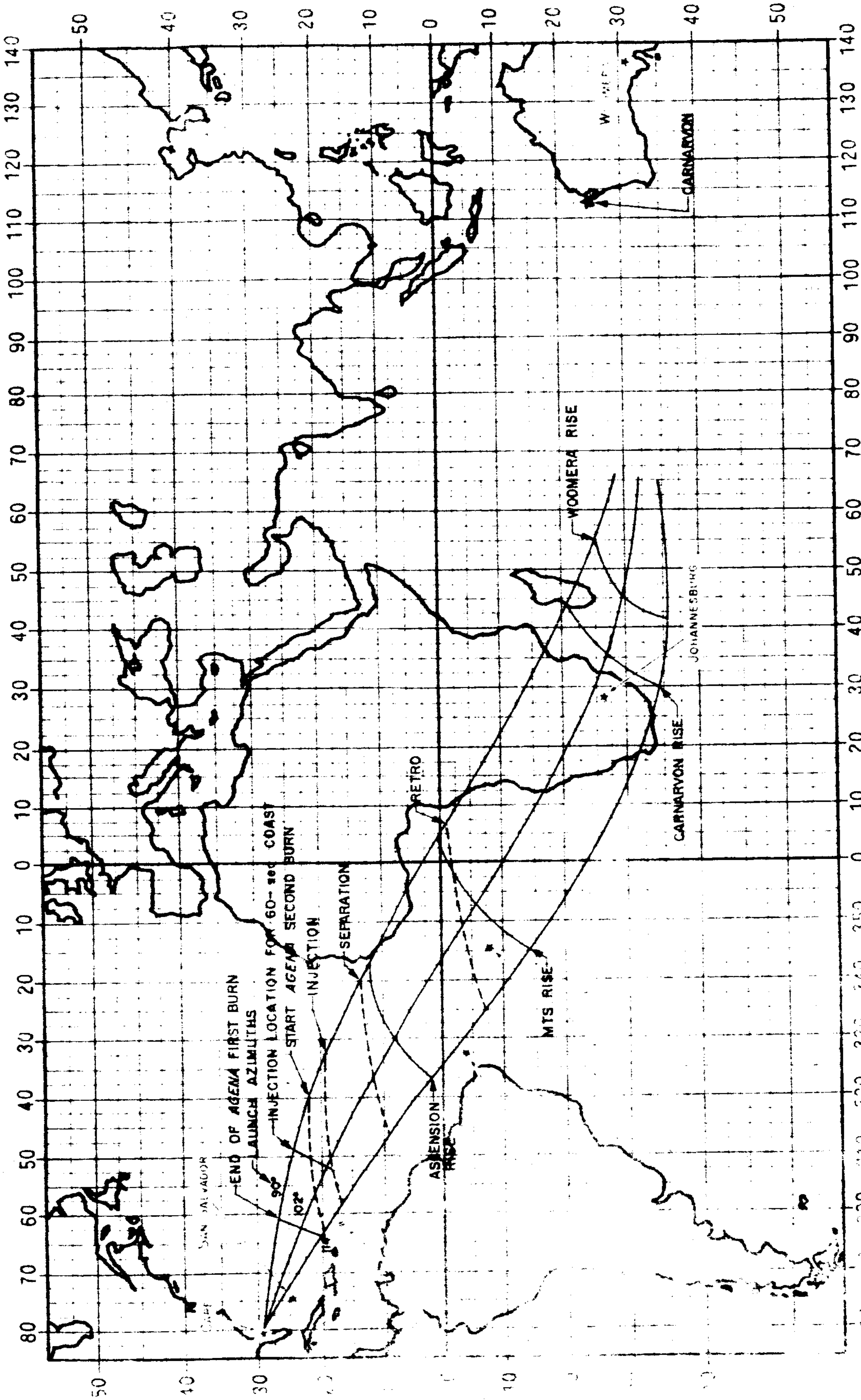

Fig. C-12. Ranger Injection Loci for Apr. 29 1964

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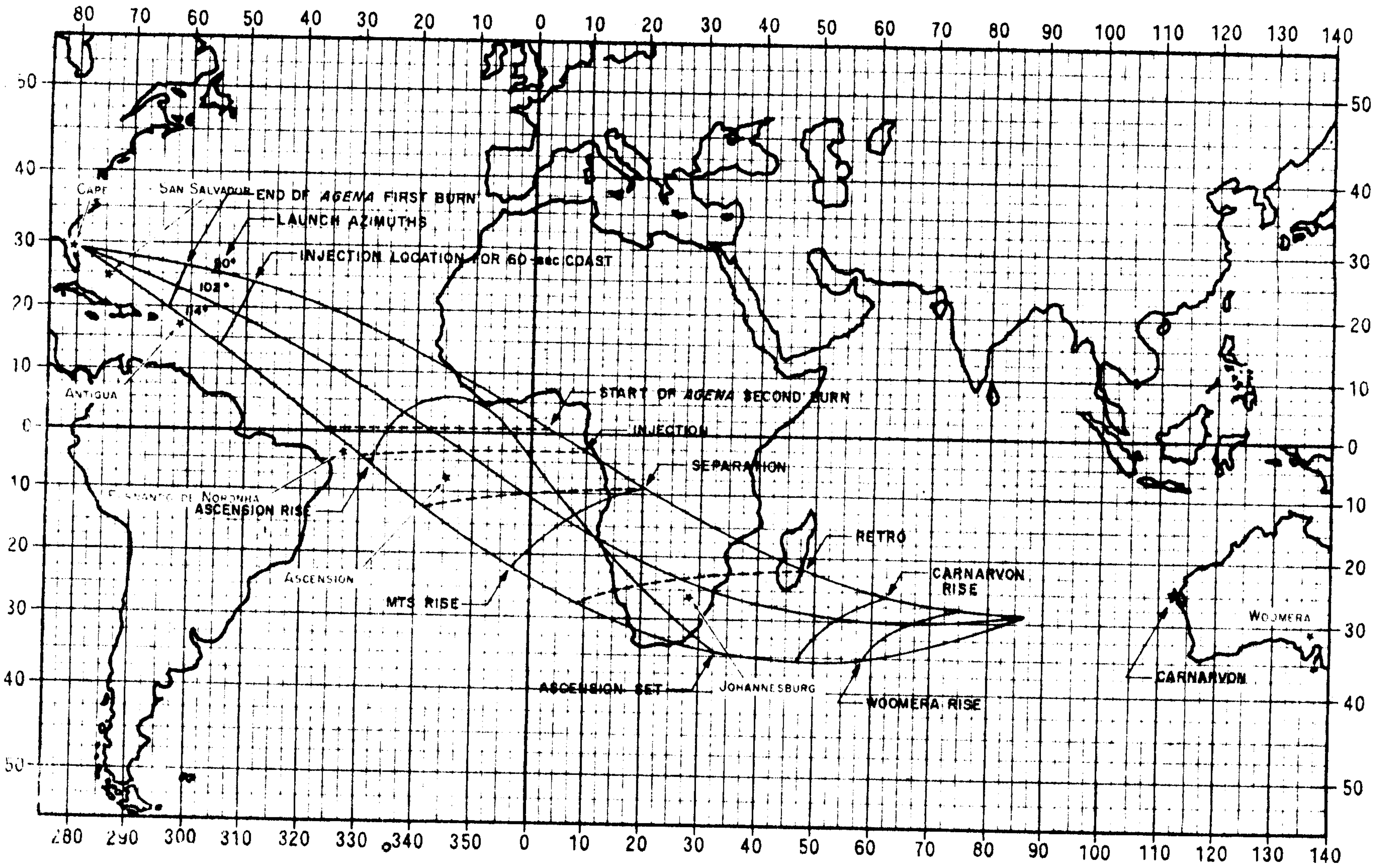

Fig. C-13. Ranger Injection Loci for May 5 1964

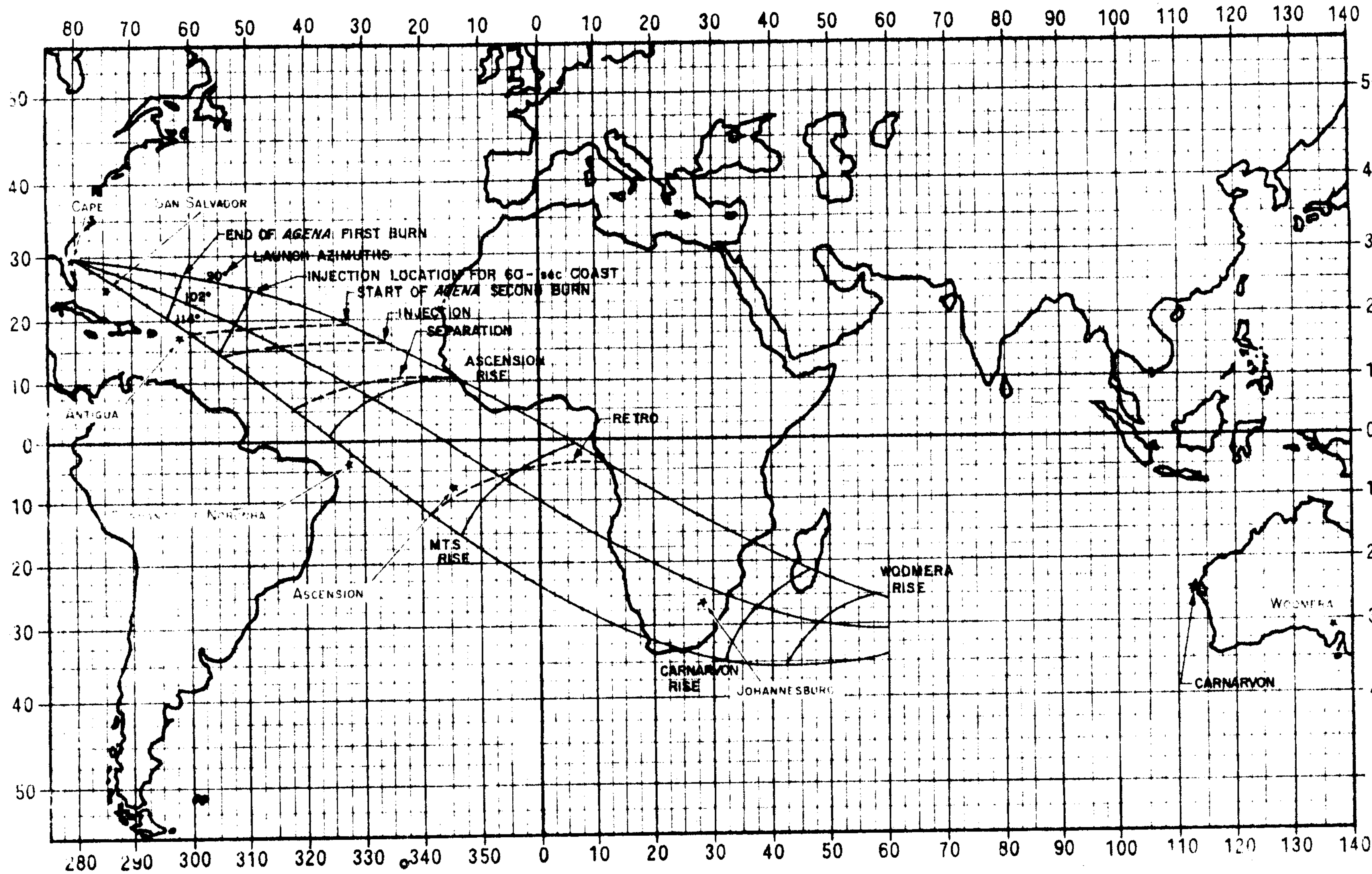

Fig. C-14. Ranger Injection Loci for May 28, 1964

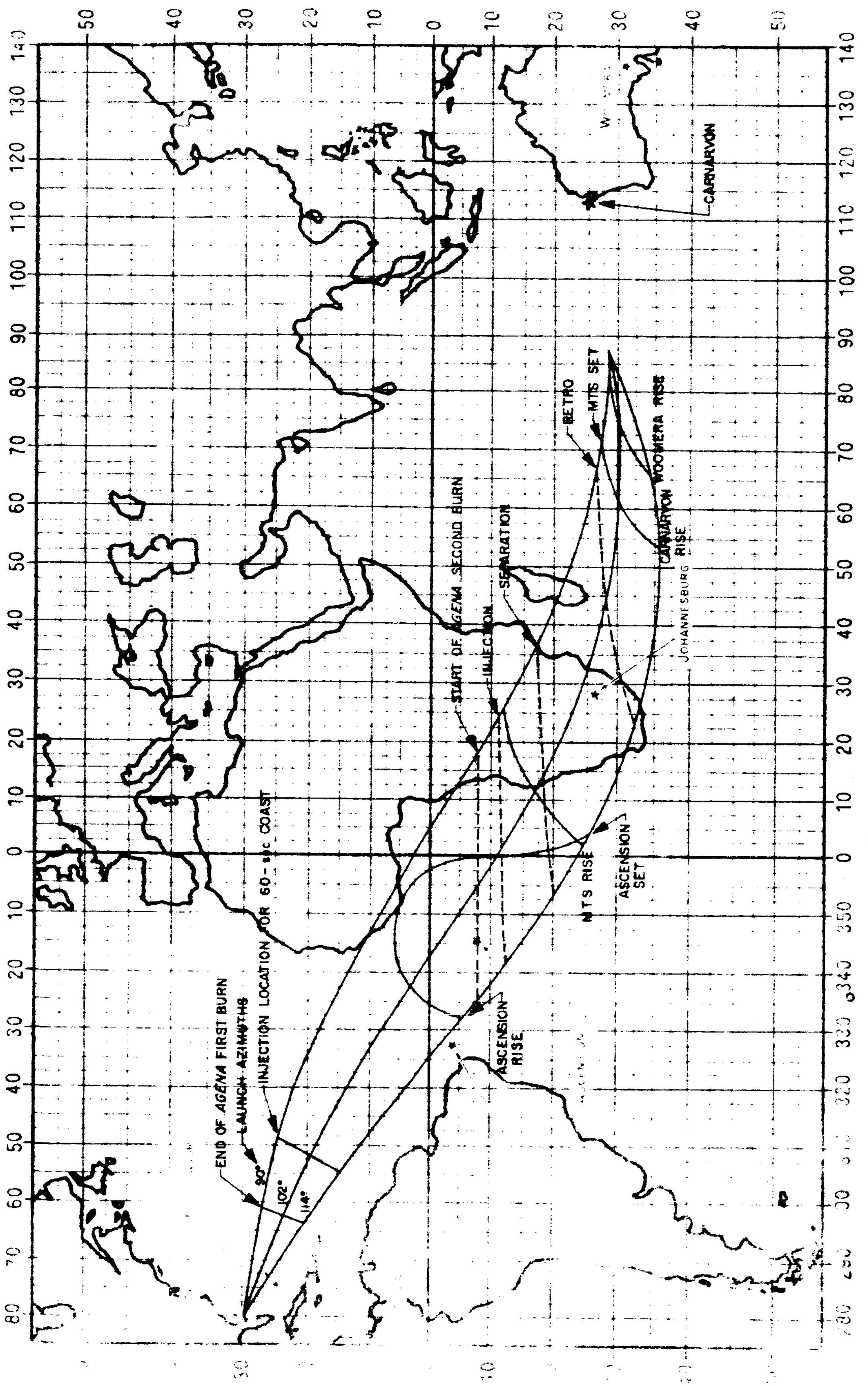

Fig. C-15. Ranger Injection Loci for June 3, 1964

APPENDIX D. Launch Constraints

I. INTRODUCTION

The purpose of this appendix is to present all the launch constraints that exist and the effect these constraints have on the design of the Launch Operations Plan. It should be remembered that no consideration is given in this issue of the Launch Constraint Document to the constraints to the launch which result from a system failure or conflicts in schedule with other projects. Rather, only launch constraints that exist even when all systems function as planned are considered.

These constraints will be described in this Appendix in the following manner:

> Paragraph II, Range Safety, describes the limits to the allowable launch azimuth sector imposed by range safety.
> Paragraph III, Spacecraft, describes any launch constraints which result because of spacecraft hardware limitations. Also, any operational requirements of the spacecraft which can constrain the launch will be treated.
> Paragraph IV, similarly describes the launch vehicle constraints.
> Paragraph V describes the constraints due to the AMR and JPL launch operations at AMR.
> Paragraph VI discusses the requirements placed by the mission on the Flight Operations Facility. Its support capability of these requirements will then be described and any launch constraints which result from inadequate support will be listed.
> Paragraph VII describes, in a similar fashion, the launch constraints which result from inadequate DSIF capability.
> Paragraph VIII summarizes the launch constraints which result from inadequate tracking and telemetry coverage.

II. RANGE SAFETY LAUNCH CONSTRAINTS

It is a requirement that all flights from AMR comply with the range safety regulations. However, it is sometimes possible to request a waiver of certain regulations if the mission objectives cannot be met within the constraints of the regulations.

There are two AMR regulations which have particular bearing on the subject of launch constraints. These regulations are discussed in Subparagraphs A and B following.

A. Overflight of Land Masses

It is AMR Range Safety standard policy to not permit vehicles launched from AMR to fly over any land mass during the flight. However, it is, in fact, impossible to conduct a lunar or planetary mission unless it is permissible for the vehicle to fly over land. Hence, it is necessary to determine how the resultant risks to populations can be minimized and still meet the mission objectives. The problem is solved by eliminating or minimizing overflight during the time the vehicle is in the ascent (powered) phase prior to injection into the parking orbit. For past Ranger and Mariner launches, this solution has resulted in a launch azimuth corridor between 93-111 degrees east of north. However, any corridor at all involves overflight of land at some point in the mission, and, therefore, a waiver of this regulation is required for all launches. This waiver request for the Ranger Block III missions was submitted in April 1963, requesting permission to launch between 90-114 degrees.

B. Agena Command Destruct

Range safety executes its responsibility for in-flight safety with a capability for command destruct of the vehicle. The range safety package includes the destruct charge itself and an RF receiver to allow initiation of the destruct charge from the ground. Range safety policy states that command destruct capability of all powered stages must exist. Hence, independent receivers must exist on both the Atlas and Agena vehicles. The capability for destruct continues throughout the ascent phase into the parking orbit. The command destruct for the Agena stage is disabled a few seconds after Agena first burn cutoff.

It is possible to request a waiver of the requirement to carry an independent command system on the Agena. This waiver would be requested if the mission objectives could not be met otherwise. This can occur if the added weight of the receiver does not allow the vehicle to inject the spacecraft into the proper escape orbit. Such a compromise of the mission objectives is generally not known until about six months before launch since the actual vehicle weights and engine performance are not known earlier.

Current indications are that the Atlas/Agena launch vehicles for the Ranger Block III missions are capable of injecting the spacecraft into the desired lunar impact orbit without removing the Agena command destruct system.

The presence or absence of this command destruct system can influence the launch azimuth sector granted by range safety, as discussed in A above. This is why this subject is treated in this document.

III. SPACECRAFT LAUNCH CONSTRAINTS

Launch constraints imposed by a normally functioning spacecraft fall into two categories:

(1) Functional requirements, and

(2) Mission objectives as they affect the mission package.

Category (1) covers such factors as the thermal requirements limiting the time in the Earth's shadow, angular and lighting limitations on the Earth sensor, and initial communications angles. These constraints are used as inputs in the initial definitization of the launch period and therefore, do not represent additional constraints as launch time.

The second category, that of the mission objectives and mission package, is also basically accounted for in the initial definitizations. However, the line between acceptable and unacceptable is not necessarily well defined. It is therefore, often desirable to define an initial period such that all potentially acceptable times are covered and then leave the final decision of narrowing of the period or windows to a later date. This refinement is accomplished as further knowledge of the characteristics of the mission package becomes available, but it is still possible to approach a particular launch period with some flexibility.

The non-standard modes are covered by the Launch and Hold Criteria which will not only define non-standard conditions and their effect upon launch, but will also cover required operations in case of a particular failure. A goal in the design and the support of a spacecraft is the requirement for a 24-hour turn around in case of spacecraft malfunction. The degree to which this has been accomplished will also be covered in the Launch and Hold Criteria.

There are no requirements or revalidations that a normal spacecraft imposes during any particular period that would place any constraint upon the overall operation.

A final possible launch constraint is the unknown effect of lightning in the immediate launch area. Criteria will be re-established to cover these conditions requiring the removal of the spacecraft in order to check any possible effect of the lightning on the squib circuits.

IV. LAUNCH VEHICLE LAUNCH CONSTRAINTS

Firm restraints for the launch period and launch window have not yet been received from LeRC and LMSC. A study is under way at LMSC to determine all vehicle restraints on the firing period and window. A completion date for the study is not known at this time. However, the following information is available and will be presented in this section. Most of the facts presented are not documented or approved by LeRC.

A. Hardware Constraints

1. Firing Window Duration

Informal information indicates that the launch window limitation will be two (2) hours, in a loxed condition, for either pad 12 or pad 13. This constraint is due to loxing limitations which are not clearly understood at this time.

2. Agena Horizon Sensor

a. Sun-in-the-Field-of-View

The Agena horizon sensor does not function properly when the sun is in the field of view. This problem does exist on Ranger missions and is recognized by both LeRC and LMSC. LeRC is currently evaluating various possible solutions in time to solve the problem prior to the Ranger 6 flight.

This problem is being monitored by the Agena Lunar Performance Panel.

b. Cold Clouds

The horizon sensor also responds improperly to masses of clouds within its field of view. LMSC and LeRC are also aware of this problem and a study is in progress to determine a solution. The Ranger Block 3 flights are again the pacing JPL mission. The Agena Lunar Performance Panel is also monitoring this problem.

c. Conclusions

At present it is not possible to predict whether or not constraints to the launch period or launch window will result due to these horizon sensor problems. However, the launch plan in Paragraph III will acknowledge the possibility that the horizon sensor can, in fact, constrain a launch.

B. Operational Constraints

The Agena vehicle is validated for launch several days prior to launch. It must be periodically revalidated thereafter. LMSC has stated that as a design goal the earliest necessary revalidation time for the Agena will be 30 days from the previous validation. Revalidation itself will require four (4) days. If J-FACT is performed on day T-7, the Agena will be validated on day T-9. Therefore, the Agena can support launch attempts for 21 days before it must be revalidated. This capability is more than adequate for the Ranger missions.

V. AMR AND JPL LAUNCH OPERATIONS CONSTRAINTS

This section of Appendix D is devoted to those areas of JPL and AMR operations at the Cape which are not covered in Sections II, III, IV and VIII.

A review of these operations has revealed that there are no constraints imposed on the Ranger launch period and launch window by these operations. Thus, launch attempts on a day-by-day basis for launch windows between 90 and 114 degrees can be supported. Again, Paragraphs II, III, IV, and VIII must be reviewed to determine whether or not constraints have been placed by JPL or AMR on the operations in those sections.

VI. FLIGHT OPERATIONS FACILITY LAUNCH CONSTRAINTS

The Ranger requirements for space flight operations are placed on the present Flight Operations Facility. These requirements are covered in a variety of documents and specifications. The capabilities of the present facilities in support of these requirements are considered in preparation of the Space Flight Operations Plan.

The facility constraints to the launch period and launch window is presented in the following Subparagraphs A and B.

A. Facilities and Personnel

The present facility is capable of supporting successive launch attempts on a day-by-day basis throughout the launch window of each day. Again, failures in part of the system, i.e., non-standard Flight Operations Facility operation, could, of course, constrain a launch. Such constraints are beyond the scope of this document.

However, the present facility is not capable of supporting a launch attempt while a previously launched spacecraft is in a critical phase of operation. The turnaround time from one critical phase to another is 14 hours. The turnaround time from a launch to a subsequent launch attempt is about 40 hours.

B. Communications

The Space Flight Operations has operational requirements for communications between Flight Operations Facility, DSIF, and AMR. RF communication links are frequently "down" due to solar flares and signals passing from daylight to darkness and vice versa. Thus, although the system is properly operating, cause for a launch hold is possible. These possible conditions for hold are described below.

a. Communications Between Cape Canaveral and JPL Pasadena

AMR provides JPL/DSIF with predictions for early acquisition and tracking requiring:

(1) A TTY line between Cape Canaveral and JPL Pasadena.

(2) A voice line between Cape Canaveral and JPL Pasadena.

b. Communications Between Cape Canaveral and AMR Downrange Stations

AMR must receive downrange tracking data for use in generating prediction data. Data needed at parking orbit injection and at transfer orbit injection require communications between:

(1) Cape Canaveral and Antigua or alternate.

(2) Cape Canaveral and the tracking station providing the post second burn tracking data.

c. Communications Between JPL Pasadena and the DSIF

JPL must transmit predictions to, and receive data from, the DSIF station(s) which is providing tracking data in support of requirements for early post second burn tracking data. This requires:

A TTY line from JPL to the required DSIF station(s).

VII. DSIF LAUNCH CONSTRAINTS

The DSIF requirements which must be met before tracking coverage can be committed have been discussed in Appendix B, Paragraph III.B.3. There are, however, additional factors which can constrain a launch, even when the above mentioned requirements are met. These requirements are discussed below.

A. Hardware

(1) DSIF view periods of less than five (5) minutes will not be committed.

(2) The length of time to convert from one operating frequency to another is two (2) hours.

B. Operational

There must be at least 24 hours between critical operations, such as the maneuver operational sequence on one spacecraft and the injection tracking of another spacecraft. This limitation on DSIF capabilities will not constrain Ranger Block III launches. (It is noted that this requirement will pose problems of scheduling beginning in the fall of 1964 when Ranger, Mariner C and Surveyor missions will be conducted during the same period.)

VIII. TRACKING AND TELEMETRY COVERAGE LAUNCH CONSTRAINTS

A. Launch Vehicle Telemetry and Tracking Coverage

1. Discussion

Telemetry and tracking of the launch vehicle during Ranger launches is usually difficult for two reasons.

First, the spacecraft Earth tracks move from east to west within the launch window during any one day. Thus, coverage must be provided over a broad ocean area.

Second, the injection loci moves up and down range in a cyclic fashion on a day-by-day basis. Thus, coverage must be provided in a different portion of the ocean each day.

An example of both these problems is shown on Figures C.4 and C.5. These figures show the most downrange and most uprange injection loci for a typical launch period. These also happen to be the first and last launch days of this period, as well. The injection loci for the intermediate days moves uprange from the December 31 location to the January 8 location. A quick glance at these figures shows that T/M coverage during the second burn and separation events is not complete across the azimuth sector. Hence, auxiliary ship support will be necessary.

However, the post-injection tracking requirement can be met on both days by tracking from either Pretoria or Ascension. Figures C.10 and C.11, however, show that ship support may be necessary to provide both the telemetry and tracking coverage necessary to satisfy the requirements. Requirements for ship coverage of telemetry during second burn is rather obvious. It would also be desirable to obtain tracking data prior to the Ascension view, to allow predicts for the DSIF sites to be calculated and transmitted in time for the Johannesburg pass. It is essential that Johannesburg data be guaranteed for these uprange injections.

The discussion has been brief and cursory as explained in Appendix C. However, subsequent issues to this document will contain an evaluation of the day-by-day support which can be expected.

2. Summary

It is obvious that ship support will be essential to the support of the Ranger missions. The degree of support will be highly dependent on the launch azimuth and launch day.

A detailed day-by-day study will be made prior to the publication of the first revision to this document.

B. Spacecraft Telemetry and Tracking Coverage

1. Discussion

Support of the spacecraft telemetry requirements will be provided by the DSIF and by the AMR L-band units and the Agena link T/M stations. It is desirable that the L-band stations be used to complement the coverage of the Agena link, thereby maximizing the total coverage capability. The coverage from the DSIF station is generally restricted to the > L + 54 minute phase of the flight. However, Johannesburg can provide important T/M coverage and its capability will be exploited where possible. The major burden for spacecraft telemetry coverage in the first hour will fall, however, on the AMR.

A detailed analysis of the support that can be expected will have to wait, however, until the AMR responds to the requirements which are now being placed on them.

Spacecraft tracking coverage will be provided only by the DSIF. A quick review of the tracking patterns for the Ranger Block III shows that it will not be particularly difficult to achieve the Class I accuracy requirements specified in Appendix B. However, several restrictions to the launch window would be necessary to achieve the Class II accuracy requirements.

2. Summary

Ship support will be necessary to meet the Class I T/M requirements. Ships are required in some instances to provide the near injection tracking necessary for the generation of DSIF look angles. Spacecraft tracking from the DSIF is usually adequate to meet the Class I tracking requirements for the pre-midcourse orbit, if both Johannesburg and Woomera are operational.